SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXIV] NUMBER 1918 NEW YORK, OCTOBER 5, 1912 [10 CENTS A COPY $5.00 A YEAR

A Controversy on Life

Two Great Biologists Differ

In the last issue of SCIENTIFIC AMERICAN we presented to our readers a brief resumé of Prof. Schäfer's inaugural address before the British Association. The present issue of the SUPPLEMENT contains the first part of a report in full of this remarkable address (see page 221), which has caused no little comment, both in England and elsewhere.

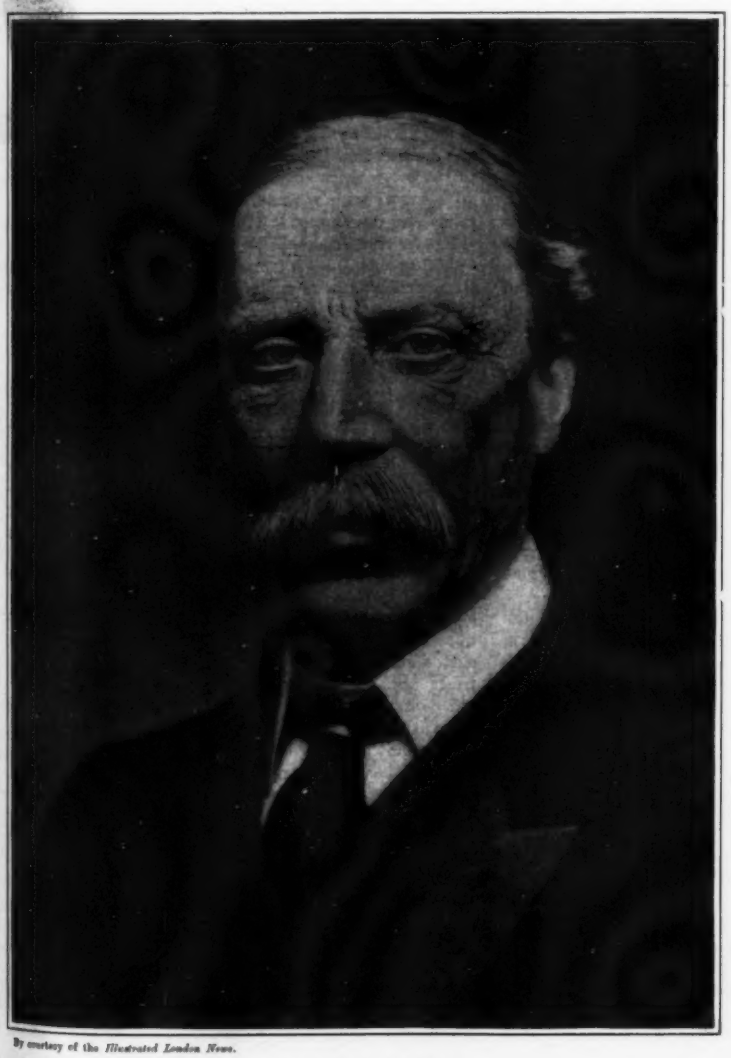
There are departments of science which, by the very nature of things, can have little interest except for the specialist. Without extended training it is impossible to grasp their significance. But there are others, whose bearing upon vital questions are so immediate and obvious that every one is necessarily interested. Unfortunately this is regarded by some as a license to take part in the discussion of questions whose significance they may, indeed, be able to discern, but which they are not otherwise qualified to debate.

Because the question of the physical nature of life-phenomena is one closely bound up with matters of personal convictions regarding the supernatural, some, whose convictions in such matters are stronger than their good judgment, and more extensive than their information regarding the physical sciences, may perhaps deem themselves equipped for a discussion of the questions involved. Such men are merely injuring, by their clumsy efforts, the very cause which they have at heart.

Fortunately, there are never wanting among the great scientific men of the day, those who have given careful thought also to the philosophic and humanistic bearing of the new developments of science, men who speak with something of the same caution and thoughtfulness on questions relating to the most sacred of human affairs which they devote to the more tangible problems of exact science. To these we may well lend a listening ear, though they themselves would be the first to warn us against any tendency of falling into the error of authority-worship.

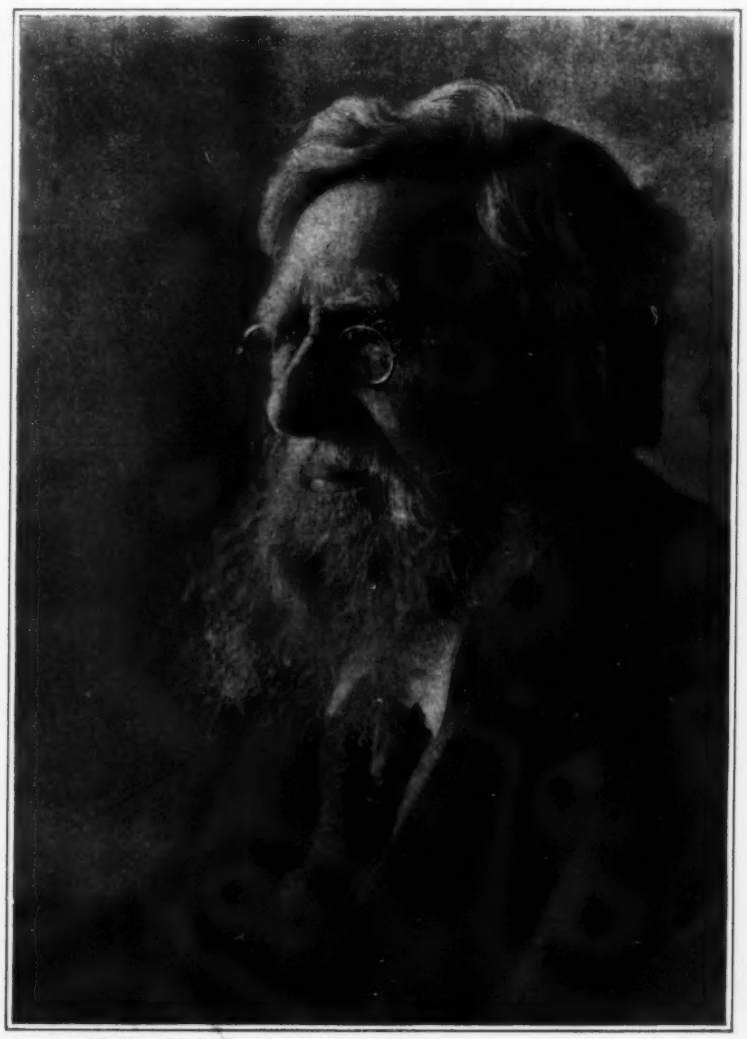
No other than Wallace, the "Grand Old Man of Science," as the editor of the *Illustrated London News* calls him, has taken up the issue raised in Prof. Schäfer's address. It is the old quarrel between vitalism and mechanism, modified perhaps in some details, but in the main unchanged. This, at least, seems to be the view which Dr. Wallace takes of the situation, for he rises in defense of the thesis that the phenomenon of life necessarily implies a guiding principle or mind. It appears to us that perhaps this point is not really touched by Prof. Schäfer. When he says that the problems of life are essentially problems of matter, he merely asserts that what concerns him is the material aspect of the phenomena involved. That such a material aspect exists, even the most uncompromising opponents will hardly seek to deny. The position taken by Prof. Schäfer, as we understand it, is, that until all the resources of the methods of investigation of the physical sciences are exhausted, we have no occasion to refer any "unexplained" effect to supra-physical causes. And Schäfer points out that most, if not all of the physical effects observed in the behavior of living matter are quite capable of being referred to purely such causes as we can see at work in non-living matter also. Spontaneous movement, growth, reproduction, these all have their exact counterpart in the inanimate world. It is true that Dr. Wallace takes exception to some of Schäfer's observations on these points. But it cannot be said that Dr. Wallace's objections appear very convincing. Thus, as regards growth, he raises the rather hackneyed argument that growth of crystals is from the surface, growth of living matter from within. This seems a trifling distinction on which to base one's conviction of a fundamental chasm between the realm of the living and that of the dead. Within and without are after all comparative terms, which rather lose their meaning when we pass from the consideration of solid crystals (which Wallace, no doubt, has in mind) to that of the recently much studied liquid crystals. After all, even in living forms, food is of necessity taken in primarily from without; that it can be subsequently diffused from within throughout the body is merely the consequence of the semi-liquid (colloidal) nature of our tissues, and the same diffusion can take place in the case of liquid crystals.

We have here singled out just one point in a controversy which it is our function to place on record, but in which we have ourselves no desire to join. The upshot seems to be that Dr. Wallace represents the thought of yesterday, of which was born the thought of to-day, so ably expounded by Prof. Schäfer.



By courtesy of the *Illustrated London News*.

Prof. E. A. Schäfer,
President of the British Association for the Advancement of Science.



By courtesy of the *Illustrated London News*.

Dr. Alfred Russel Wallace,
Who shares with Darwin the credit of originating the Theory of Evolution.

EVOLUTION AND THE ORIGIN OF LIFE

The Bubonic Plague—II*

Its Menace to the United States of America

By Howard D. King, M.D.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 1917, page 195, September 28, 1912

To appreciate how plague might secure a foothold in the eastern portion of the United States, it becomes necessary to consider the trade relations enjoyed by New Orleans, Mobile, Galveston, Pensacola, Key West and Tampa, in the order named. The sea trade of these cities is very large, and there is constant intercourse with Mexico, the Central American republics, Panama, West Indies and the northern and eastern ports of South America, and, in addition, indirect communication with the west coast of South America through the Isthmus of Panama railway. In a lesser degree the following ports also enjoy trade relations as above described: Gulfport and Moss Point, Mississippi; Savannah, Charleston, Norfolk, Baltimore, Philadelphia, New York and Boston.

The prolonged struggle in Mexico between the Federal forces and the Revolutionists not only is a source of annoyance from the point of view of commerce and business, but also adds an element of danger in that plague might be unrecognized in that country, be carried across the Texas border and be rapidly diffused throughout that State and the Central West by prairie dogs, rabbits and squirrels.

It is necessary at this point to digress and consider the position occupied by the Isthmus of Panama.

In reference to the Isthmus of Panama, it must be remembered that it occupies a unique position, in that it is one of constant exposure to many tropical diseases. The question as to the future of the Canal Zone itself, following the completion of the canal, is one of importance. Col. Goethals, engineer-in-chief of this great undertaking, has suggested to the Isthmian Commission that the country contiguous to the great canal, except that portion required for the habitations of the military force necessary to its protection and the canal employees, be allowed to return to its pristine wildness. This suggestion is undoubtedly due to the fact that the completion of the Panama Canal means the abandonment of the great health organization which has maintained such a high standard of sanitation. The ports on the western coast of South America have been in constant communication with endemic plague centers for at least eight years. Each year the disease, in its insidious approach, creeps nearer. La Guayra, on the east, and Guayaquil, on the west coast of South America, both plague-infected, are only three days' journey from the isthmian ports and are in constant communication therewith. The Royal Mail Steamship Company, plying between infected ports of Venezuela, refuses to carry deck passengers to Colon, but allows first-class cabin passengers to embark for the same point. With this anomalous condition, can we keep Panama and the chain of Central American ports on the Atlantic side free from plague?

This question has been answered with the advent of plague in Porto Rico and Cuba.

To-day we have a widely advertised feature of travel, known as the sight-seeing of the canal, which is patronized by people from every section of the United States. When one remembers that these travelers coming from the United States must necessarily be thrown in contact with travelers coming from the plague ports of South America, it is not difficult to appreciate the ease with which plague may gain entrance into the United States. And it must be remembered that the bulk of travel from the isthmus is via New Orleans, and cases might get through, despite the most stringent precautions. The majority of the ships engaged in this trade are manned by Chinese crews, and, considering the receptivity of these people to a tropical infection, such as plague, they constitute an element of danger that cannot be easily waived. The vulnerability of New Orleans by sea invasion ought to be readily apparent.

The larger portion of the tropical trade enjoyed by the Atlantic and Gulf Ports is what is known as the "green fruit" trade. This industry is enormous and increasing daily. But here let me turn aside and pay a tribute to the principal corporation engaged in the "green fruit" trade, the United Fruit Company, American, for the adoption of a rigorous sanitary policy in dealing with all classes of tropical affections, special attention being given to the problems of plague and yellow fever. Through the general medical superintendent of the United Fruit Company, Dr. Robert Earl Swigart, stringent regulations dealing with ship sanitation and fumigation are enforced. Each ship of this company carries a well trained medical man, who is especially conversant with tropical conditions. In addition to caring for the welfare of the passengers intrusted to their care, the surgeons of the company are practiced in ship sanitation and fumigation. The rat-killing crusade as recently inaugurated by this company, under the supervisorship of Dr. Swigart, in ridding their tropical possessions, such as wharves, warehouses, plantations, and also ships, of rodents is really commendable and a deserved recognition of the value of that branch of latter-day science known as preventive medicine.

These, as briefly as could be stated, are the facts regarding our danger of plague infection from the American tropics. That they are serious is obvious, especially when we know that the type of plague prevailing in this section possesses to a high degree every characteristic of the present pandemic.

There are also in our midst certain dangers the prompt recognition of which will aid in minimizing any danger arising in the near future. It is not my purpose to burden this paper with facts of common knowledge, but a survey of actual conditions is necessary for the maintenance of this discussion. In the first place, many of the ports of the South Atlantic and the Gulf have suffered in the past from outbreaks of epidemic infections, such as yellow fever, and to-day certain of them, such as New Orleans and Mobile, are the homes of many tropical diseases. Therefore, at the outset every southern port may be considered as a predisposed community to such a disease as plague.

With plague threatening the United States, especially the maritime cities of the southern and eastern coast, the time for action has arrived. To the South this warning should be shouted from every hill-top and go reverberating through every dale and valley, before too late.

The plague situation in the American tropics to-day is alarming. Despite its interest to the southern portion of the United States it has thus far been given but scant attention. The completion of the Panama canal will increase the seriousness of the plague situation, but all thoughts of this are left unuttered in the hopes of the trade and commerce that will accrue to the South as a result of the completion of this great engineering feat. Material prosperity, however, invariably brings in its train evils of many descriptions. "Trade follows the flag," and "disease follows trade." To-day every southern port, and especially those of New Orleans and Mobile, are in close relationship with lands in which devastating epidemic diseases, particularly the plague, are rife. In the shipping cities of the South, health and disease-prevention seem to be ignored to a great extent and to be in subversion to trade interests. The lay press disregards the situation as much as possible, and in the laudatory articles dealing with the commercial upbuilding of this section of the country no mention is made of the menace of the disease. Plague, indeed, seems to be the skeleton at the feast.

The promotion of the trade deserves encouragement, and material prosperity is doubtless a goal to be eagerly sought. But these will be dearly bought if at the same time plague is introduced.

The sanitary conditions of many of the cities of the South are truly deplorable. Conditions in New Orleans, Gulfport, Mobile, Pensacola, Tampa, Key West, Savannah and Charleston, unfortunately, are most favorable for the concealment and spread of plague. The combined population of the above ports is 601,568, of which number at least 269,000 are negroes. This large number of negroes, alone, presents a health problem of serious magnitude. While the negro does not participate in the civic life of the community, he is a factor of no small import in the social and economic affairs of the South. The mode of living among the negroes of the South violates almost absolutely modern sanitary regulations. Many of the whites of this region also approach the negro in the lack of personal hygiene and debasing influences and surroundings. And when we stop to consider that the percentage of illiteracy in the extreme southern and south-eastern part of the United States is the highest in the Union from a sectional point of view, it will be seen that the South has problems of immensity aside from possible plague invasion. In recent years there has also grown up throughout the South a very large Italian population, including many Sicilians. These people are but a few degrees removed from the negro, and in some instances worse, so far as personal hygiene and sanitary environments are concerned.

As it is to-day the southern United States has manifold medical problems which prevent that section progressing socially, politically and economically. The retarding effect on education and civilization of malaria, uncinariasis and pellagra are illustrative of what I mean.

The chief object in directing the attention to what may be termed a sectional or geographic predisposition to plague is to dispel that impression of safety—that belief of assurance—that plague cannot and never will reach our shores.

As to plague ever infecting the Mississippi Valley, the chances are not so remote as one would at first glance imagine. To my mind, the infection of the Mississippi Valley, if it occurs, will be brought about by the disease appearing in New Orleans and being transmitted up and down the river through the agency of the steamboat and the negro roustabout. This line of reasoning is based on the fact of the close proximity of the steamboat landing with that of wharves reserved for tropical steamers. Intercourse between the rodents of these two styles of craft will be difficult to prevent. Next to a granary, a steamboat acts as the ideal home for rodents. Infected rodents once gaining access to the steamboats will prove dangerous to the health of negro roustabouts. The negro roustabout, on account of his habits, would readily fall a victim to the disease, and, owing to the migratory tendencies of this type of negro laborer, the disease will be spread far and wide.

What effect plague would have on such animals as the rabbit and squirrel, which are exceedingly numerous throughout the South, also remains to be seen. In the light of our present knowledge, an epizootic of plague among the squirrels and rabbits is not only possible, but extremely probable; and there is no use denying that they would spread infection far and wide, and especially among the negroes and poorer whites who live principally on these two animals when in season.

To-day the dock or harbor front of every port of the South Atlantic and Gulf of Mexico presents a most inviting condition for the introduction and transmission of plague. The wooden docks and wharves of these ports are dangerous. From one end of these different ports to the other there stretch rows of wooden wharves, and all overrun with rodents. The method of discharging cargo and dunnaging in these ports is not at all proper. Cargo or freight should be placed above the ground, so as to prevent rodents from gaining access thereto in the easy manner now possible. Ships coming from tropical ports are not properly supervised by the health authorities. Ships on which rodents abound tie next to the wharves and, in seeking food, the rodents find their way ashore and mingle with the native rat. If the ship rat is infected, the natural results may be easily imagined. Extra precautions should be taken with ships engaged in the fruit, sugar and coffee trades and hailing from tropical ports. Ships' hawsers and cables are in no single instance or, indeed, very rarely protected by rat shields and trapping devices. Absolute safety demands nothing less than rat-proof landings, piers and wharves in every port on the Atlantic seaboard and Gulf coast.

Very close to the docks of these cities and within a stone's throw of the ships berthed to the wharves are located warehouses, freight depots, grain elevators, packing and cold storage plants, burlap and bag factories, cotton compresses, stave yards, stables and other industrial plants and institutions, all of which, it is safe to say, are overrun by rats. It has been shown that to gain access the ship rat has but a short distance to travel. It is here that the intermingling of the native and ship rats will play havoc. Many of the above buildings are old, and in many instances poorly constructed.

There also exists in connection with the industrial section, thus described, a condition peculiar to southern cities, and that is that the living districts—thickly populated—of the poorest and most illiterate type are hemmed in between these industrial sites. They are, to be exact, located, at intervals of five or six blocks, between the plants and establishments to which reference has been made. There also exist in these neighborhoods sailors' lodging and boarding houses and innumerable saloons and eating houses—many of the lowest grade. The larger proportion of the structures in these vicinities and the streets closely adjacent thereto are antiquated, dirty, in ill repair and devoid of all sanitary conveniences, and certainly must be considered as having some bearing on health problems. The average citizen has no idea of the rat population of localities devoted to shipping.

* Studies from the Laboratory of Tropical Medicine and Hygiene under the direction of Creighton Wellman, Tulane University of Louisiana, published in the *Journal of the American Medical Association*, July 27th, 1912.

The majority of the inhabitants of these sections are in some manner connected with the maritime trade of the ports—a phase of the question that is to be considered in discussing the transmission of plague, either by direct or indirect infection. The recreation and relaxation for these people, to a great extent, is found in spending the evenings by the wharves, and, in some instances, ship visiting. Accordingly, these localities—and there are others—may justly be considered predisposing to any type of disease which might arise. Were we to single out these centers, and from the point of view of sanitation and hygiene compare them to the other sections of the cities previously spoken of, the result would justify terming them the pathologic spots of the community.

Again, many of the cities of the South Atlantic seaboard and Gulf coast are full of structures confined to no particular section, harboring rats underneath their wooden floors.

The rat-proofing of stables, restaurants, warehouses, grain elevators and residences for the various shipping centers of the South presents an appallingly large and complex problem. The experience of San Francisco, nevertheless, proves that it is feasible. The adoption of these measures alone will ensure to the South and the rest of the United States a reasonably permanent safeguard against the spread of plague, should it be introduced. A laboratory should also be equipped for examination of all rodents killed or found in the vicinity of the wharves and docks of the different ports. Without delay there should be established in every shipping center a non-infectible zone between the residential section of the city and water front. For the accomplishment of this drastic reform sanitary measures should be directed to the exclusion of rats from the wharves and first tiers of industrial blocks.

Earnest co-operation between the people and health authorities in the enforcing of all necessary health regulations should be secured. The attitude of the press toward radical, though absolutely necessary, health measures should be friendly, and not antagonistic or disparaging. The interests of the commercial organizations of the entire South must be aroused, and the fact must be impressed on them that discussion and truth as to sanitary shortcomings are better than the policy of concealment and silence often practiced in the past. The education of the people as a whole regarding the dangers of the rat should be conducted in the same manner as was the anti-mosquito campaign in New Orleans during the yellow fever epidemic of 1905.

The measures necessary to secure the desired results would be substantially as follows: The building laws of the various ports would have to be amended to provide that hereafter all structures should be made rat-proof—particular attention being given to the construction of floors and side walls and plumbing arrangements. Stables, private markets and places in which foodstuffs are kept should be given marked attention. Existing structures should be made rat-proof whenever deemed necessary, according to proper standards to be announced by health officials. Insanitary buildings or structures, or parts thereof, should be declared nuisances, and provisions made for the rectification of such conditions. Basements, back sheds and the open spaces beneath buildings should likewise be made rat-proof. Landlords should be made to realize that proper rat-proofing of their property is an investment which will greatly enhance realty values. If necessary, the rat must be "built" out of the maritime cities of the South by the use of concrete, brick and stone in the foundations and side walls of all buildings.

Adequate regulations concerning the collecting and disposal of garbage should be adopted. Householders should be required to keep garbage in metal receptacles and tightly closed. Street paving and cleaning should be brought up to the highest possible state of efficiency. Wooden bridges and crossings should be abolished.

The commercial and shipping interests should be taught that the inauguration of an anti-rat crusade would prove of considerable economic advantage, and in a short interval they would probably become the strongest supporters of the work.

All docks and wharves should be so protected as to prevent rats from gaining entrance to them, at either high or low stages of the water, from vessels berthed alongside such docks and wharves. Food products stored in docks or wharves should be so arranged as to make it impossible for rats to gain access thereto or come into contact therewith. The wooden docks as seen in New Orleans, Mobile and other ports are obsolete and form ideal harboring and breeding places for rats, opening avenues for infection from South or Central America, the West Indies or even the Orient. In regard to wooden docks and wharves the ports of the North Atlantic occupy the same position as New Orleans and the balance of the southern ports. The building of stone or concrete wharves is costly, but not prohibitive. Where possible, wharves should be protected from rats by fending vessels off shore. This should apply particularly to vessels from suspected ports. Hawsers and lines leading ashore should be protected by either rat shields or rat funnels. Ladders and gangways should be lifted at night, after the work of discharging is concluded for the day. As considerable difficulty would be experienced in wharf regulations, their enforcement would depend on competent policing.

The one thing for which the harbor or dock commissions of the interested municipalities should provide is a rat-killing brigade or corps whose duty would be to wage a constant war on rodents in and about wharves. In addition to their labors about the docks, they should also be sent aboard ship on arrival to rid it of rats. One of the interesting sights on arrival at the port of London is to observe the red-uniformed band of rat killers come aboard ship and commence their operations before the passengers have even disembarked.

In conclusion, I believe the time is ripe, indeed, that it is absolutely imperative, that a plague conference be held. This conference should be held in either New Orleans or Mobile, preferably the former, and should have for its objects the prevention of plague importation, the enactment of regulations looking to the wholesale extermination of the rat and the improved sanitation of all the southern ports. A uniform and efficient system of ship fumigation should also be discussed at this conference. The health officials of every southern State should be invited to participate. If possible, the conference should be held under Federal auspices. In order that it prove a success the conference should be widely advertised and the aid of all trade organizations and commercial bodies be solicited.

It would il become us to point the finger of scorn at other countries for neglect of modern methods of sanitation, while we continue to disregard similar precautions in our own ports. And finally, let the words of Emerson sink deep, "Obedience alone gives the right to command."

Photographic Observation of Comet 1911 c* (Brooks)

By E. E. Barnard

THIS comet was discovered by Dr. W. R. Brooks at Geneva, N. Y., on July 20th, 1911. Perihelion passage occured on October 27th.

At first it was a faint object. Even with photographs of long exposure at this time there was no evidence of a tail. The comet was simply a round nebulous mass, a little brighter in the middle, but with no nucleus. It brightened rapidly, but was slow in developing a tail. By August 20th the comet was faintly visible to the naked eye as a hazy spot of light, but the tail was not seen until about September 16th. It became a splendid object in the evening sky in the latter part of September, when its slender tail attained a length of about 25 degrees. When near perihelion in the morning sky it was especially bright and beautiful. It was one of the finest comets of recent years and the duration of naked-eye visibility, about four months, has been exceeded but by few comets. At its best it was but little inferior to Halley's comet. Though a large one, it was not a great comet in the correct sense of the word. The regular parabolic rim outlining the head and tail was not formed. Even at perihelion small streamers at considerable angles to the tail were still present. These small streamers are usually absent in great comets, in which the outline of the head sweeps back to form the boundaries of the tail when the comet makes a close approach to the sun, and all the small side streamers are swept back into the main tail.

Up to the middle of October, the comet was a great disappointment from a photographic standpoint, for, though bright and conspicuous to the naked eye, its effect upon the sensitive plate was very slow, and long exposures were required to show the tail, which was simply a straight and rather narrow stream of diffused matter, with nothing of interest except occasionally an effort at additional streamers near the head. The photographs were very much alike, night after night it looked as if the comet would not be of any special importance. This condition continued until near perihelion, when it suddenly became an object of the deepest interest and showed a wealth of detail in the structure of the tail that has been equaled by only one comet (Morehouse's) since photography has recorded their spectacular changes. At the same time its photographic action increased very greatly, apparently much more than was due to its actual increase in brightness. Morehouse's comet, which was relatively a faint object, and just dimly visible to the naked eye for a couple of days, was not only remarkable for the great changes that took place in its phenomena, but was also singularly active in its effect on the photographic plate, requiring comparatively short exposures to show the full extent of its tail, which was too faint even to be seen in the telescope. The spectroscope showed the presence of cyanogen strongly in this latter comet, and to this fact, was attributed its great photographic activity and the unique features which developed in its tail.

The second, or active, period of Brooks's comet showed similar characteristics of details and photographic effect, but, though cyanogen was present in the head, it was, so far as I can learn, not shown to be present in the tail. It might therefore be suggested that it was not really cyanogen that was responsible for the peculiarities of Morehouse's comet. Many of the phenomena resembled those of Morehouse's comet, and though not so weird in some of its features, it was on some occasions more beautiful than that object, from a photographic standpoint, and of course visually, it was infinitely finer.

One fact, that is strikingly apparent in the photographs of Brooks's comet is the remarkable reduction in the size of the head as it neared perihelion. On September 18th and 19th, the actual diameter on the photograph was 1,200,000 kilometers, while on October 28th, it had diminished to 510,000 kilometers.

At first the head was large and round, and the tail where it joined it was a narrow thread—a "neck"—as if the two had no more connection than a mere attachment. This is shown by the measures on September 18th, when the head was 54 minutes in diameter and the "neck" only 6 minutes. As the comet approached the sun, the head diminished in size, while the "neck" correspondingly increased, until finally the two became nearly of the same size, the outlines of the head more or less merging into and forming the outlines of the tail.

This phenomenon always occurs in the case of comets that make any near approach to the sun and is doubtless due to the increased pressure of the sun's light upon the matter of the comet which is thus driven out in the direction of the tail. But the photographic evidence of the phenomenon is a very beautiful one.

* Abstracted from the *Astrophysical Journal* for July, 1912.

The Horse-power and Kilowatt

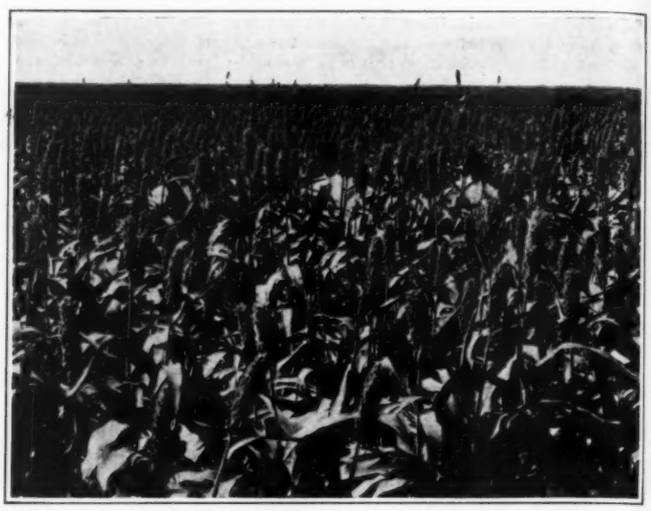
THERE was, before 1911, no precise definition of the horse-power that was generally accepted and authoritative, and different equivalents of this unit in watts are given by various books. The most frequently used equivalent in watts, both in the United States and England, has been the round number, 746 watts; and in 1911 the American Institute of Electrical Engineers adopted this as the exact value of the horse-power. It is obviously desirable that a unit of power should not vary from place to place, and the horse-power thus defined as a fixed number of watts does indeed represent the same rate of work at all places. Inasmuch as the "pound" weight, as a unit of force, varies in value as g the acceleration of gravity varies, the number of foot-pounds per second in a horse-power accordingly varies with the latitude and altitude. It is equal to 550 foot-pounds per second at 50 degrees latitude and sea level, approximately the location of London.

The "continental horse-power," which is used on the continent of Europe, differs from the English and American horse-power by more than 1 per cent, its usual equivalent in watts being 736. This difference is historically due to the confusion existing in weights and measures about 100 years ago. After the metric system had come into use in Europe, the various values of the horse-power in terms of local feet and pounds were reduced to metric units and were rounded off to 75 kilogramme-meters per second, although the original English value was equivalent to 76.041 kilogramme-meters per second. Since a unit of power should represent the same rate of work at all places, the "continental horse-power" is best defined as 736 watts; this is equivalent to 75 kilogramme-meters per second at latitude 52 degrees 30 minutes, or Berlin. Circular of the Bureau of Standards, No. 34, June 1st, 1912, gives tables showing the variation with latitude and altitude of the number of foot-pounds per second and of kilogramme-meters per second in the two different horse-powers.

These values, 746 and 736 watts, were adopted as early as 1873 by a committee of the British Association for the Advancement of Science. The value, 0.746 kilowatt, will be used in future publications of the Bureau of Standards as the exact equivalent of the English and American horse-power. It is recognized, however, that modern engineering practice is constantly tending away from the horse-power and toward the kilowatt. The Bureau of Standards of the Department of Commerce and Labor and the Standards Committee of the American Institute of Electrical Engineers recommend the kilowatt for use generally instead of the horse-power.—*Mines and Minerals.*

Hardening Agent for Steel.—Salt, 910 parts; saltpeter, 115 parts; carbonate of iron, 115 parts; borax, 213 parts; wood alcohol, 7,000 parts; glycerine, 4,750 parts, and oil, 19,000 parts.—*Niueste Erfindungen und Erfahrungen.*

Stacked Broom Corn. A Plant Which is Developing Remarkable Drought-resisting Qualities.



A Field of Kaffir Corn. The Stalks Are Used for Cattle Fodder, the Grain for Human Consumption.

Discovering Utilities in Desert Crops

Wanted: A Patent System to Protect "New Agricultural Products"

By Z. E. Black

WHEN old Nebuchadnezzar received the edict to "go to grass," he would not have fared so badly even though his grazing grounds had been a desert, if he had had the advantages of the discoveries of modern scientists in the matters of discerning and developing food values in the "grasses of the field" that are native to arid and semi-arid regions. Plain farmers and ranchers, spurred on by necessity, have performed successful experiments and introduced innovations without the assistance of the learned man of science, and other utilities than food values have been found to be possessed by desert plants.

Referring to "bear grass," which sucks its sustenance from the sands of the desert, only a few years ago the scientist, or rather the scientific manufacturer, showed the world that rope and bagging and a cheap grade of paper could be made from this hitherto supposedly worthless plant. Later still it was found that the fiber from its coarse spines could be woven into Panama hats. But the arid country is shorter on fresh vegetables than anything else, and since the natives discovered that the bud of the bear grass blossom, when cooked, counterfeited the taste of asparagus or English peas, their interest in the same has been growing apace.

Bear grass is a son of the genus "Yucca," natural order *Liliaceæ*. There are several other members of the family known as "Adam's needle," "Spanish bayonet," etc. But what the scientific name of bear grass is, does not matter. The vernacular is a perfectly good name, though why "bear" grass, is not known unless perhaps the wily bears used its spines for toothpicks or ate its blossoms as a cat nips catnip. Anyone who has traveled across the arid sections of the West and Southwest has observed it, because, as a rule there is nothing else observable. It flourishes in beds of sand and grows even in sections where the annual rainfall is not sufficient to rust the bottom of the Government rain gage. Although bear grass is related to the Yucca family and the stately palm tree, the last two have never acknowledged the kinship of the former lowly member as it has until recently been regarded as a hopelessly worthless "black sheep." Now that bear grass is bringing $7 per ton and is satiating the fastidious appetite of the epicure, there appears to be a chance for it on a limb of the family tree.

In some portions of west Texas and over a majority of New Mexico and Arizona and in some other Western States, within the past two years the cutting, baling and shipping of this succulent plant have increased to a mammoth and important industry. Almost every small railroad town is shipping around 5,000 tons of the baled product per annum. Twelve months ago it brought $5 per ton; now the price is $7, and there is every indication that it will shortly be "bulled."

Five acres of average land are required to furnish a ton of the dried and baled hay. The plant is cut with a mattock, just below the base of the bulb, so that none of the spine-like leaves may be wasted. Cheap Mexican labor is often employed, which allows the contractor a good margin of profit. After the plant has been separated from its roots, it is then quartered to expedite the drying process. Even after being split longitudinally into four parts, for six weeks does the desert sun have to stay on the job before the grass is sufficiently cured for baling. Desert plants are alike dilatory in growing and in drying. It is baled like any hay, into 250 pound bales, 3×2 feet in dimensions. From 250 to 300 of these bales comprise a carload. Most of the cars are billed out to St. Louis, where the American Manufacturing Company and other companies have their factories or their agents.

So far no landowner has objected to having his bear grass cut unless he wants to handle it himself. However, it is thought that if the price continues to soar, this commodity will soon be cultivated as a commercial crop. For it is independent of weather conditions, and in the cultivated fields that have been turned out by some disgusted "homesteader," this grass has been observed to spring up from its roots to a height of two feet in a single year, a much more rapid growth than where the soil has never been broken. Cutting the bear grass always fails to kill the roots; in fact the plant appears to rather like the process.

The grass blooms early in the summer, running up a stem sometimes to the height of six feet. Around this stem and its offshoots are clustered copiously the panicled, greenish-white, odorless blossoms. Cattle are very fond of these blooms and would devour them all but for the fact that the uppermost ones are beyond their reach—doubtless so designed by nature. Some resourceful Western woman, spurred on by a desire to "have something new for dinner," tried cooking the buds of these flowers, and the results were most gratifying and

Baled Bear Grass Around "Homesteaders" Shack, of Which There is one to Every 160 Acres in New Mexico.

appetizing. A dish of boiled bear grass buds, set before a blind person who has ordered asparagus tips, will be eaten without questions and with a relish. Some are pleased to believe that the dish tastes more like green English peas. At any rate the writer can testify that it is most palatable.

In the little town of Portales, N. M., the bear grass or Yucca, is considered the "national flower," and the crates of cantaloupes from the irrigated farms are trademarked with a picture of the same. The crop never fails and it comes in quite handy to pay off land notes, or when the revenue from its sale assists the impecunious homesteader to eke out a livelihood while "living out" Government land.

Other zerophytic or drought-loving forms of plants are being pressed into service of man and beast. When one takes a drink from a chunky barrel cactus, he feels that he has become almost as skillful as an Indian. The system is to cut off the top with a heavy knife, pound the water-laden interior with some implement until the fiber breaks and soft, spongy pulp results; the fluid is then squeezed by hand from the pulp into some receptacle. It is of a whitish color and tastes about like plant juice in general—but it is WET, and when, in the desert, one's canteen has sprung a leak, one is not prone to be choicy about how he "irrigates."

The prickly pear—any plant of the genus *Opuntia*—which flourishes on the barren ground in the southern, eastern and western portions of the United States, is becoming quite popular as a feed for cattle. Several years ago the cattlemen observed that their stock would eat this plant when other forage was scarce on the range, but the "stickers" were a great drawback—a regular "thorn in the flesh." Some one conceived the idea of cutting this cactus, holding it with pitchforks over fires of mesquite wood, and thus singeing off the spines which so annoyed the noses of the cattle, and, presumably, their throats and stomachs as well. The result was very satisfactory and "toasted prickly pear" now occupies an important position on the menu card for cattle in many portions of the cow-country. Burbank has "dehorned" this cactus, and as it is a great milk-producer, the prophecy is made that prickly pear without the "prickles" will in time be cultivated extensively in the arid sections, its natural home.

Alfalfa is often claimed for a desert crop, so generally does it appear in the arid countries. For, given water, this clover can endure the onslaughts of the "hot winds" better than most crops. The damming of streams and the empounding of floodwaters in usually dry arroyos, and the pumping from wells with centrifugal pumps, are furnishing the wherewithal to irrigate this crop, and in many shallow water districts alfalfa is sub-irrigated by its roots reaching to the subterranean strata. Seemingly endless are the uses to which alfalfa can be put. It is an excellent feed for any kind of stock, whether green or used as hay, and especially happy are "pigs in clover." But now greedy man is grappling with the hog for this choice crop. Banquets are frequently given where only alfalfa products are served—alfalfa bread and cake; alfalfa roots cooked into an acceptable substitute for asparagus; alfalfa syrup which is not "bad to take;" alfalfa tea and coffee, and no doubt the cigars which follow contain a fair portion of alfalfa or some other hay, as usual. Not only are these alfalfa products palatable, but they are pronounced by eminent physicians to contain valuable nutritive and tonic properties. Throughout the arid countries, alfalfa becomes more popular each year, and the natives believe that in time its products will satisfy all the calls of the most capricious appetite.

When the resourceful dwellers in the arid and semi-arid regions discovered that corn would not grow there

with such limited rainfall, they searched about and hit upon kaffir corn and milo maize. And they have petted, preened and picked over these plants until varieties have been developed that are much more drought-resistant than were their earlier crops. As kaffir and maize become more important, a diversity of uses for them is being worked out. They have been shown to be almost as valuable for stock feed as Indian corn, and a couple of years ago they were granted a rating on the grain exchange. The kernels are an excellent substitute for popcorn for the "kiddies." Various breakfast foods and cereal drinks are now being manufactured from the grain, leaving the stalks for fodder—an advantage over corn. A good grade of bread, cakes and other pastry can be made from the flour and meal that are ground from the little white kernels. On the slices of bread made from alfalfa or maize flour, may be spread excellent pink jelly concocted from the juice of the "algerista berry," the red fruit of a desert shrub of the currant family. Of course, if you happen to muss your hands or mouth in the ensuing gustatory process, you can wash them in water obtained from the cactus plant—for soap, using the lather obtained from beating to pulp the bulb of the "soap-weed," which is another name for the bear grass.

If your granary is depleted, the slender, sweetish beans of the mesquite tree prove a relished provender for your horse. In some places they are regularly harvested. No use has as yet been found for the "blue weed," but the bothersome "Russian thistle," which is threatening to take the West, if cut at a certain age rivals alfalfa in the hay produced. The less rain the thistle gets, the better it grows—in fact it dies down in particularly wet years. "Johnson grass" was for a long time regarded as a menace, but the farmers of the West are taking kindly to it since it will grow in dry climates, and, on account of its reproducing both from the seed and the root, being almost invulnerable to drought. This grass is also desirable on account of its ability to add humus to the soil, and so to destroy its "wild nature."

In fact, the people of the desert districts are beginning to believe that every plant that is native to their section has some usage, often several, either for man or beast. It has only been a few years that these utilities were systematically sought for. The newcome settler always tries out first the crops to which he has been accustomed in the rainfall districts, and in the end the rigors of the desert defeat his efforts. The country has answered his appeal for aid with gigantic irrigation projects. But it is a well-known fact that the total water supply, both below and above, is inadequate to irrigate more than one tenth of the land. When every cupful of water is being utilized in irrigation ditches, then will the developing of useful plants that will grow under arid conditions without irrigation and the searching for utilities in the natural desert crops be pursued in earnest. A system should be devised whereby the experimenter who gives to the world a variation of a plant, educated to withstand the droughts, or who discovers a new use for a desert growth, may be protected and rewarded by a patent.

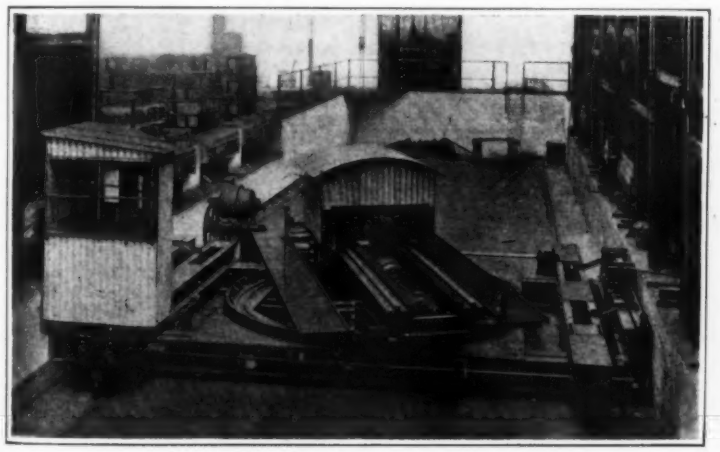
But considering that the efforts in the above lines of development have been brief and at best, haphazard, the results are truly astonishing. For most of the pioneers have been selling land and town lots, talking irrigation and experimenting with "dry farming" without considering the characteristics or possible worth of the plant life about them. The few men who have searched for these utilities are the greatest benefactors to their country. Not only have they increased the present means of revenue getting many times, for their people, but they have turned the spotlight on hardy plants, the nature of which must be thoroughly known before the work of introducing foreign and more valuable crops into the desert can be pursued intelligently. For instance, the type of the root system, the cell structure, the form of the shoot and leaf, the chemical composition, and many other qualities of the plants of the grass family which are most closely allied to wheat, and which are natives of the arid regions, must be carefully studied before such qualities can be induced in wheat, and thus adapt it to desert conditions. There is ample scope here for the modern agriculturist to apply scientific methods with good effect.

However, the $7 per ton for bear grass, paid on delivery at the car, is not to be sniffed at in these strenuous times, and it appeals more to the average, horny-handed homesteader than the silent clamor of unborn millions of "back-to-the-landers" for crops that will have been acclimatized to the desert or hybridized with desert plants at a date in futurity when all the rainfall sections are crowded. And when one considers the varied delicious concoctions that can already be made from pounding or grinding and cooking the sturdy, camel-like crops of the desert, it is quite comforting to know that if we should be ordered to "go to grass," even in the land of the mirage, we should not necessarily fare so badly after all.

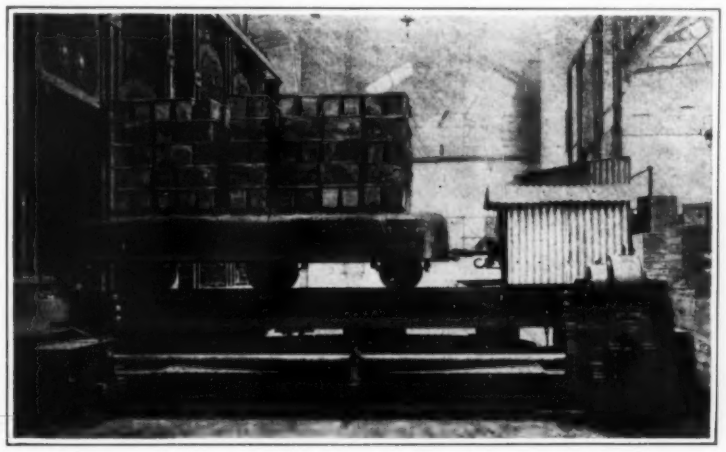
A Thirty-ton Electric Traverser for Serving Annealing Furnaces

An interesting form of traverser specially designed for use in connection with the charging of annealing furnaces, is described in a recent issue of *Engineering*, at a Scotch iron foundry.

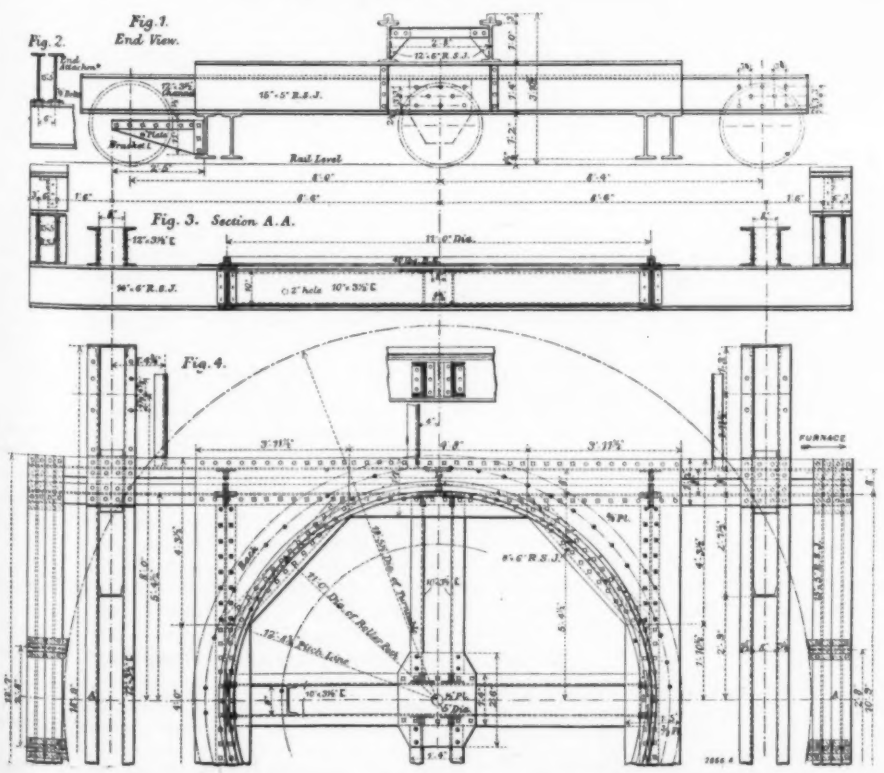
We produce therefrom a series of drawings showing the details of construction, while the two half-tones show the traverser in its completed state. Referring to these, it will be seen that the traverser consists of a main carriage running on a two-rail track laid along the floor of a pit, on each side of which are situated the loading-bays and furnaces. Mounted upon this main carriage is a revolving table provided with a track, upon which a

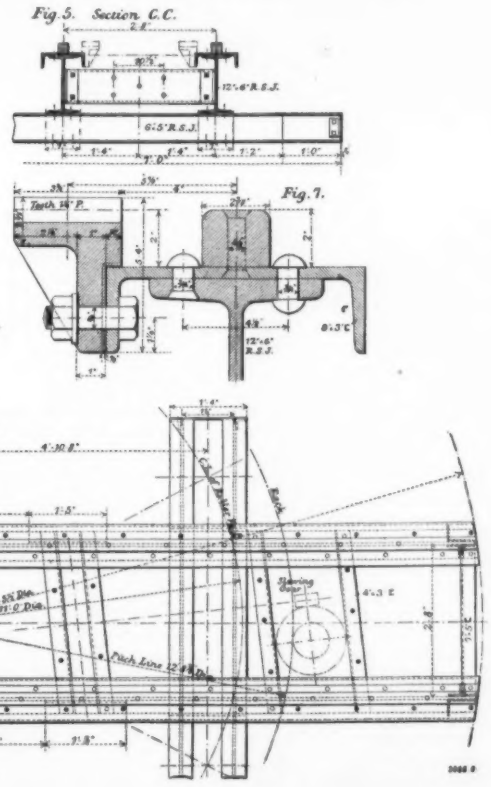


General View of Electric Traverser.

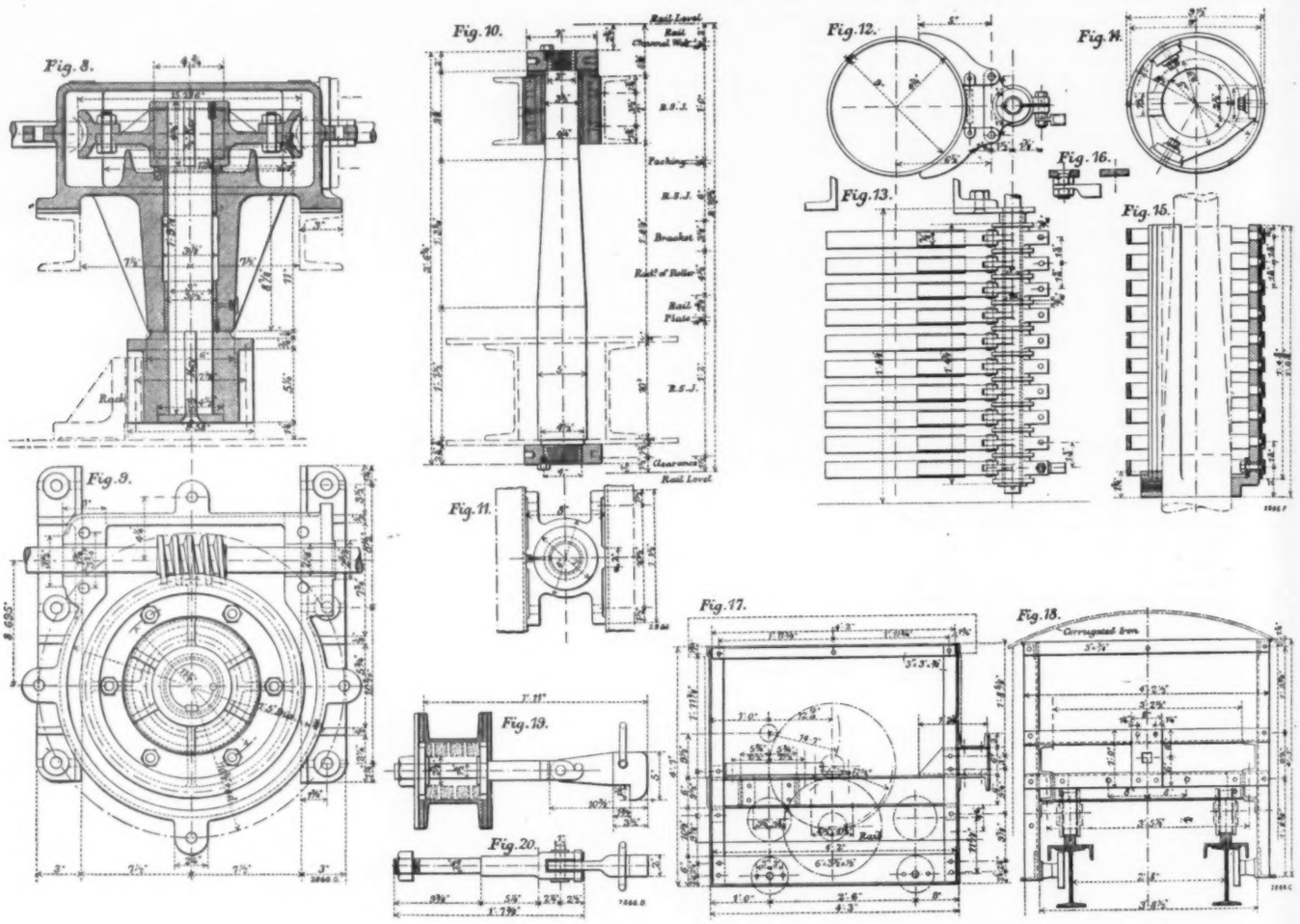


Traverser Charging an Annealing Furnace.





Details of the Traverser and Turntable.

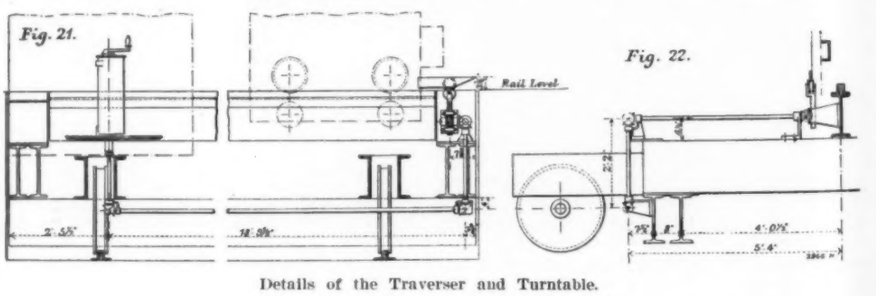


haulage carriage runs, this last being employed to handle the bogies upon which the annealing-pots are stacked. As will be seen from the two half-tones, the track upon the revolving table is at the same level as the rails in the loading-bays and those laid in the furnaces, and thus by suitably maneuvering the machine the bogies can be carried from one to the other in a convenient manner. The three movements of the traverser—namely, traveling, revolving the table, and traversing the haulage carriage—are each operated by a separate electric motor, the current for which is taken from trolley-wires carried in a chase in the side wall of the pit, and the whole of the control-gear is situated in the operator's cabin, placed to one end of the main carriage, and from which a full view of all the operations is readily obtained. As will be explained later, the switch-gear is provided with interlocking mechanism arranged to prevent movements taking place out of their proper sequence.

The details of the main carriage are shown in Figs. 1 to 4, from which it will be seen that six running wheels are provided; two of these wheels are gear-driven from the motor, the arrangement of the drive being clearly seen in the second picture. Upon this carriage is fitted a circular track, upon which the upper table runs, revolving around a central pivot, which is also fixed in the main carriage.

In Figs. 5, 6, and 7, are given details of the revolving table, while in Figs. 8 and 9 is shown the gearing for this motion. This gear consists of a vertical spindle-carrying a pinion, which is driven through a worm reduction gear by the motor, which, with the gear, is mounted on the revolving table. The pinion engages with a circular rack, shown dotted in Fig. 8, fixed on the main carriage outside the circular track already mentioned, as will be seen by reference to the two half-tone illustrations at the head of this article. Details of the pin about which the table revolves are given in Figs. 10 and 11. The main girders of the table carry the track rails for the haulage carriage and also the racks from which it is driven, the method of attachment being shown in Fig. 7.

The haulage carriage, which is built up of steel sections and is inclosed in a corrugated iron casing, is shown in detail in Figs. 17 and 18. As already mentioned, it runs on the track on the revolving table and is driven by pinions gearing in the fixed racks referred to above. As shown in the drawings, guard-rollers are fitted to prevent the carriage from tipping and also to prevent it from running off the track. Fitted at one end of the carriage is the haulage hook, of which details are given in Figs. 19 and 20, while this is further seen in the general view.



Details of the Traverser and Turntable.

The current taken from the trolley-wires, already mentioned, is led to a switchboard in the operating cabin and thence to the three motor-controllers. In the case of rotating and haulage motors the leads from the controllers are taken to the distributing device shown in Figs. 12 to 16. This consists of a casting, fitted to the center spindle, carrying a series of brass collector-rings insulated from the casting. To each of these rings one of the leads from the controllers is connected by means of sweating thimbles shown in detail in Fig. 16. Fitted to the revolving table is a brush arm carrying a series of insulated brush-holders, to each of which the leads to the motors are connected, while each holder carries a pair of brushes held in contact with the corresponding ring by a spring, as shown in Fig. 12. The leads corresponding to the revolving motor are taken direct to the motor, while those for the haulage motor are connected to the trolley wires on either side of the crab track, and seen in the headpieces. By these means the crab and revolving table can be traveled or rotated to any desired position without the use of flexible cables.

The operations performed by the traverser are as follow: The bogies are first loaded with the boxes containing the castings to be annealed, and are then brought to a track at the end of the traverser pit. The table is then placed in line with this track, and the bogie drawn on; the traverser is then brought in line with the furnace to be charged, and the table turned through 90 degrees, so as to bring its track in line with the furnace track, when the crab pushes the loaded bogie into the furnace. In discharging the furnace a similar procedure is followed, but in this case the table is rotated through 180 degrees to place the bogie on the cooling bed, which is on the opposite side of the pit to the furnaces.

As mentioned above, a system of interlocking is provided to prevent overrunning, and consists of mechanical locks on the motions together with interlocking on the controllers. On the revolving gear a positive lock is fitted which prevents motion through more than 90 degrees, and this lock, being connected with the control-handle, cuts off the current from the motor and thus prevents further movement until the lock is withdrawn. In connection with the main travel a lock is fitted which brings the traverser to rest in the correct position before each furnace, and at the same time puts out of action the revolving and traveling motor-controllers until the lock is again withdrawn.

On the haulage motion the controller is interlocked in the manner shown in Figs. 21 and 22, above. In this case the crab carries a depressing skate, which, on the crab nearing the outward end of its travel, comes in contact with the vertical rod carrying the roller shown. This rod is thus depressed, and by means of the gear and shafting shown puts the controller into the "dead slow" position independently of the operator. The bogie is thus brought to rest against the back of the furnace without fear of damage to the wall. The machine is designed to deal with loads of 30 tons, and the speeds of operation are as follow: Main travel along the pit, 60 feet per minute; revolving table, one revolution per minute; travel of haulage crab, 30 feet per minute.

Memorial to Eustachio

THE Italian anatomist whose name is widely known in connection with the Eustachian tube of the ear, has, on the occasion of the four hundredth anniversary of his birth, been honored by the erection of a memorial tablet in the house inhabited by him at Sapienza, near Rome.

An Experimental Study of Vortex Motion in Liquids—II*

Lord Kelvins's Smoke-ring Model of the Atom

By Prof. Edwin F. Northrup, Ph. D., Palmer Physical Laboratory, Princeton University

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 1917, page 205, September 28, 1912

SIMPLE QUALITATIVE EXPERIMENTS.

By means of the brass rod which supports the gun, and the rod which tilts it in a vertical plane, it may be quite accurately pointed in any desired direction. By applying 110 volts directly to the magnet, the ring which issues from the gun will go the entire length of the tank in about one half second, and the gun may be aimed so that it will hit the lens at the far end of the tank fairly in the center. When the ring is near the lens it begins to expand, and will increase, at the moment of striking, to several times its original diameter. The ring is best observed end on through the lens as it approaches. It is seen to be about 1.9 centimeters in diameter, or 1.5 times the diameter of the hole in the tube. Its form is quite symmetrical and resembles a small anchor-ring. The diameter of the solid portion is about 3.1 millimeters and the hole in the center is between 12 and 13 millimeters. When observed through the glass at the side, the path of its motion is seen to be straight and its velocity gradually diminishes as its distance from the gun increases.

It should be particularly observed that the same material, the colored water which leaves the gun, moves bodily from one end of the tank to the other. It is thus possible to project for a distance of over a meter rings of a strong alkaline solution through a solution strongly acid. If the water of the tank contains suspended particles of slightly greater density than water, the ring will pass through and among them without incorporating and carrying them along with it. Thus sifting Indian meal into the water in the path of the ring it was found that none of the particles were taken up by the rings.

Another pretty experiment in this connection is to hold in the path of the ring chiffon cloth stretched over a frame when it will be found that the ring passes easily through it without being broken up or disturbed in its motion.

The kinetic energy of these rings is considerable. If a piece of tissue paper similarly stretched, be held in the path of the ring, the ring will break through it, but in turn is broken up by the impact. If a light watch-chain hangs in the water, and is fairly struck by a ring, it is bent into a decided curve by the force of the blow. This power of the ring to bend a chain was used to advantage in some of the later photographic work when timing the ring and the drop of a photographic plate.

If a gun is placed at each end of the tank and two rings are shot simultaneously in opposite directions it is observed that, if they meet fairly, both are broken up and dissipated; but, if their line of approach is such that they might be expected to touch on their edges on coming near together, they bend out of a straight course and pass without an encounter or injury to their form.

The swiftly moving rings described above may have their speed reduced as much as desired by inserting resistance in the gun circuit. The slowly moving rings are easier to observe and may be quite as perfect in form as the more rapidly moving ones, and for many experiments it is better to make slow rings, but as they move with less contained energy the phenomena of impact, deviation from the straight path, when approaching one another, and the vibratory phenomena are less marked and less well defined.

When the gun is tilted so as to shoot a ring toward the surface of the water it is, on reaching the surface, reflected in a very beautiful manner. As the surface of the water is approached the upper edge of the ring gains a little in velocity over the lower edge, so that the plane of the ring tilts through an angle, equal to the change in direction of the line of approach to the surface. In other words, the plane of a moving vortex ring is always maintained normal to its direction of motion. As near as could be judged from observations, the laws of reflection are the same as those of light rays. It sometimes happens that a ring approaches the surface of the water when this is disturbed by a wave motion and is not level. Under such circumstances the angle of reflection may appear quite different than the angle of incidence, but this is probably due to the indeterminateness of the latter angle. There is a certain critical angle which the line of approach of the ring to the surface makes with the normal to the surface of the water, at which the ring will not reflect but jumps out of the water with a spurt. The results of four carefully made trials to determine the value of this critical angle are given in the subjoined table. The diagram, Fig. 5, accompanying the table makes clear the meaning of the symbols used. We have, $\sin \beta = \frac{h}{l}$, hence $\beta = \sin^{-1}\frac{h}{l}$.

Trial.	h cms	l cms.	sin B	B	θ
1	16.2	44.5	0.364	21°, 21′	68°, 39′
2	30.3	78.3	0.387	22°, 50′	67°, 10′
3	34.2	82	0.417	24°, 40′	65°, 20′
4	9.3	25	0.372	21°, 50′	68°, 10′

It is possible to produce refraction of the rings as well as reflection. To accomplish this the tank is half filled with water and then with a rubber hose a dense solution of salt or barium-chloride is carefully siphoned into the tank at the bottom so as to make a layer of liquid denser than water underneath the water. If a high velocity ring be now shot so as to pass at a slight angle from the water into the denser salt solution below, it will be observed to pursue a path which is slightly curved downwards. This experiment was not tried out as carefully as could be desired, but it seems certain that the path of the ring is considerably deflected in passing through media of different densities. It is probable, though no exact measurements were made, that the velocity of the ring diminishes when it passes from the lighter to the denser medium.

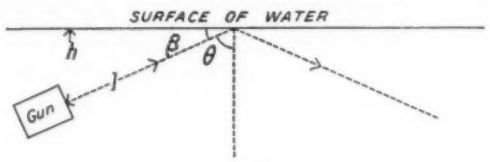


Fig. 5.

Rings which are ejected from a very exactly circular hole are always round and advance through the water with no other visible motion than that of progression. If, however, the hole in the gun is elliptical, vortices are formed and progress as before, but they assume, in addition to their forward motion, a vibratory motion. The vibrations are such that the vortex changes from an ellipse with its major axis vertical to an ellipse with this axis horizontal. The vibrations are almost too rapid to be followed distinctly with the eye. It is a most interesting sight to observe such a vibrating ring as it moves throughout the entire length of the tank, especially if it is observed through the lens along its line of motion.

Triangular and square holes also give rise to vibratory rings. But the most remarkable property of water rings is observed when the end of the gun is provided with two holes, one above the other. In the experiments tried the two holes were each 0.85 centimeter in diameter with 2.55 centimeters between their centers. The two rings, which issue simultaneously from the two holes, begin to attract each other as soon as they leave the gun, and at a distance of about 6 to 8 centimeters from the gun they come together with great suddenness and form a single ring of twice the circumference of one of them. The ring so formed proceeds with apparently the same velocity as a single ring to the end of the tank. It has, however, vibratory motions that are remarkable. Unlike the single ring, which issues from an elliptical hole and vibrates in one plane only, the ring formed by the union of two rings has a much more complicated vibratory motion in planes normal, and parallel to the direction of forward motion of the ring. The peculiarity of this motion will be better understood from references to illustrations given later. These vibratory rings will also reflect from the surface of the liquid but it is doubtful if the angle of reflection is equal, always, to the angle of incidence, as the angle of reflection will depend upon the phase of the vibration of the ring at the moment when it reaches the surface.

Novel and unexpected results were obtained when the surface of the water in the tank was covered with a layer of kerosene oil from 5 to 10 centimeters deep. To render more apparent any phenomena which might happen the oil was given a deep red color. It may not be generally known that all ordinary dyes and coloring materials will not dissolve in oils but sink to the bottom without imparting to the oil any color. At least 20 or 30 coloring stuffs, including many aniline dyes, were tried before one was found which would impart a color to kerosene oil. Of those tried, two only were found which would color kerosene. One is known as alkanet root and the other is a coloring material known under the trade name of Soudan III. Both materials were tried but the latter is the more satisfactory and imparts to the oil a deep rich red color. It will also color carbon-tetrachloride, acetone, paraffin, all oils and probably many other chemicals, but is entirely without effect on water. A thimbleful of this dye was used to color two or more gallons of kerosene, which was then floated upon the surface of the water in the tank. The gun was located about 30 centimeters below the oil and aimed so as to project rings toward the surface of the oil at an angle, adjusted by trial, so that the water ring would enter the oil. The result was surprising. The water ring on entering the oil instantly became converted into an oil ring. This oil ring continued to move to the upper surface of the oil, where it was reflected, and moving downward entered the water as an oil ring and continued to move until broken up by its encounter with the end of the tank. The results were, of course, just the same whether the water in the gun was, or was not, colored. With no coloring matter in the water the vortex ring of water was invisible as it approached the oil, and the illusion was given of red oil rings issuing from the oil without any apparent agency for their production. After the ring broke up, the oil of the ring rose to the surface of the water and united with the main body of the oil, and this process could be continued indefinitely. It was, however, necessary to wait about a quarter of a minute between the shooting of successive rings as the surface of separation between the water and the oil required such time to regain its quiet and smoothness, after the agitation caused by the passage of a ring through the surface. It was found that to obtain oil rings in the above manner the angle at which the water rings were projected toward the oil had to be adjusted within rather narrow limits. This adjustment could easily be made, however, after a few trials. If an oil ring was projected with such a velocity that it nearly lost its forward motion before striking the end of the tank, the oil constituting the ring would segregate into small globules. The small globules would continue for a time in rapid circulation about the vortex filament. This rapid movement, in small circles, of the oil globules, in apparent defiance of centrifugal force, was a very striking and interesting phenomenon.

(To be continued.)

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Falsification of Evidence by Suggestion

FROM the writings of Prof. Münsterberg we are all familiar with the irreliability of the human memory and the dangers and pitfalls which arise therefrom in the matter of legal testimony. Some very interesting examples illustrative of these facts are cited from his own observation by Prof. Dück in *Umschau*. In order to test the memory and susceptibility to suggestion of his pupils he performed the following experiment on forty-eight boys between the ages of fourteen and seventeen. He passed a silver coin about the size of a fifty-cent piece around the class, instructing each boy to carefully examine it, but giving no further indications as to the purpose of his action. At the end of the lesson, which in other respects proceeded as usual, Prof. Dück, having again taken possession of the coin, addressed the class as follows: "You have no doubt observed that the coin which I handed around had a hole in it; now I would like to test your powers of observation. I am, therefore, going to ask each of you to indicate the point on the coin where the hole is found. Just take a piece of paper, draw a circle upon it, and indicate roughly the position of the head on the coin and of the hole which you observed." As a matter of fact there was no hole in the coin at all. Nevertheless no fewer than forty-four out of the forty-eight pupils indicated the position of the alleged hole in the coin, some even indicating the position of two holes. Of the four remaining pupils, only one positively asserted that there was no hole in the coin, the other three merely said that they had not observed the hole. This alone is interesting enough, but there were several other features in the case which are well worth recording. In the first place the one and only individual who had not been open to suggestion was a boy who had previously shown his independence by giving considerable difficulty in matters of discipline. Furthermore, several of the younger boys, even after they were told that there was no hole in the coin, absolutely refused to admit this. It hardly needs to be pointed out how significant an observation of this character is in its bearing on legal testimony. We must not be surprised that the witness may under certain circumstances not merely make a certain statement incompatible with facts, but may even insist in his erroneous belief in the face of overwhelming evidence against it—and all this in perfectly good faith.

A Chapter in Industrial Sanitation

Vacuum Cleaning Applied to Machinery in Textile Mills

By J. B. C. Kershaw

THE elimination of dust and floating fiber from the carding rooms of cotton and woolen mills is gaining considerable impetus owing to the introduction of various systems of extraction by vacua. Up to a comparatively recent date the exhaust fan held its own, as the clarifier of the cotton mill especially. It appeared in the windows, walls and ceilings at intervals of 10 to 30 feet; and has done much to convert close, effete atmospheres into cool and comfortable working areas. And were it not for the growing necessity, owing to the prevalence

The Stripper at Work on the Doffer of a Carding Engine.

of flat-carding machinery, of applying exhaust in a more localized form, the suction fan would still have a fair share of patronage in the textile industries.

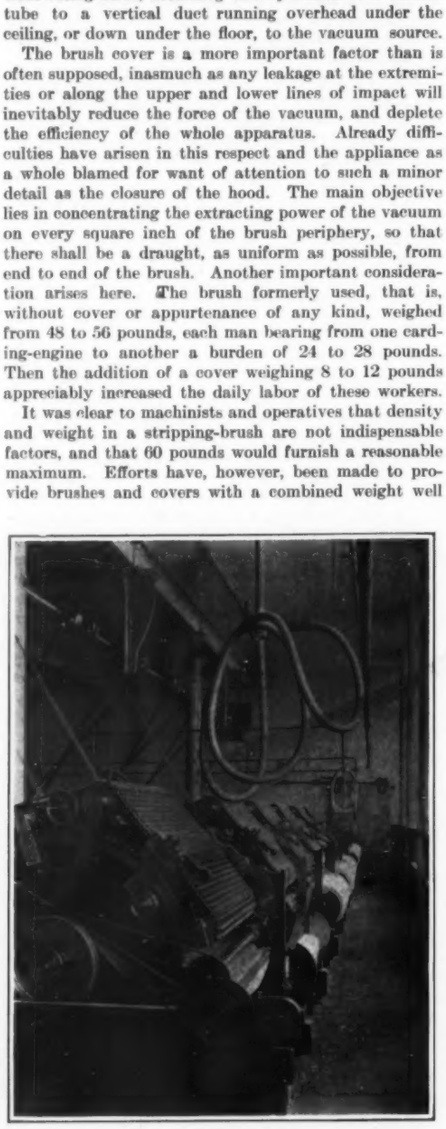
It has been clearly demonstrated that the fan in the window or wall does not efficiently remove the dust and fiber generated during the process of *stripping* the carding-engine cylinder and doffer. The location of carding-engines in cotton mills is on a universal plan. The machines are arranged in lines of twenty to fifty, in proportion to the productive faculty of the mill, in a longitudinal direction as near as practicable to the line of windows. It is admittedly an undesirable policy to scatter the carding machinery in different parts of the mill, as the effective transport of cotton laps from scutchers to cards would be considerably hampered. Hence, direct lineage of carding engines is adopted for the double purpose of good lighting and easy transfer of the manufactured material. But this favorable position also promoted the insertion of fans in the windows or walls adjacent to these lines of machines; and thus it was sought to draw off directly from the carding-engines all dust emitted while stripping and grinding were being carried on. Obviously, this method might be of some value when dealing with machines within a few feet of the fan-blades, but when machines are treated at a distance of 20 to 50 feet from the fan, the exhausting power of the latter is not only useless but damaging to the intervening atmosphere, as any motion induced by the fan current causes the dust to be diffused over the machinery and the workers employed thereon.

To obtain a clear atmosphere it is absolutely necessary to remove the stripping-dust and short fiber at the point of origin, and to convey it by means of ducts and flues into some form of collecting-chamber. There is no distribution of the deleterious matter in the air of the room, the channel of removal being clearly defined. "Stripping dust" is a well-recognized entity in all mills devoted to the processes of cotton spinning. It is fairly specific in its nature, and under the lens of a powerful microscope reveals various elements not generally known owing to the finely-divided state of the constituents. But we have little difficulty in discovering parts of the bark, leaf, stalk and seed of the cotton plant; there are also seeds of other plants which become diffused over the cotton field. These, in themselves, are materials which cannot do otherwise than damage the breathing powers of the operatives. But the dust also contains particles of sand, quartz and minute specks of metal. These are not innocently curved so as to be comparatively innocuous when grazing the mucous membrane of the pulmonary tubes; they are awkwardly angular, and frequently the metallic particles are hooked so that after inspiration their expulsion from the air-passages would be difficult indeed. Asthmatic and lung troubles have long followed in the wake of stripping-dust; and the present effort seeks to prevent its deleterious elements from reaching the breathing-line of the workmen who, in pairs, must clean or "strip" the card cylinders three or four times daily. With the fans in adjacent windows or walls these men are invariably immersed in a cloud of dust given off from the machine; their duty is to stand by and watch the progress of stripping, and though many strippers have adopted the plan of using respirators or wads of cotton fiber, it is impossible to escape from the "cloud."

The vacuum method of extraction has come into vogue in cotton mills largely as a sequence of its adoption for domestic purposes such as dusting of walls and carpet-cleaning. The suggestion arose that if a vacuum could be used in extracting dust from a floor-cloth or carpet the same principles might be adapted to the elimination of dust from the carding-engine. And the various appliances in use are directed to the removal of dust and fiber at their point of origin, just as in the case of a carpet or wall of a room. One requirement has been fully recognized from the first as of paramount import. The stripping-brush extends the full width of the machine and comprises a central shaft and hollow cylinder covered with wire "bristles." To collect the dust from these bristles either the whole brush must be efficiently inclosed in a hood, or the hollow cylinder must be perforated. In either case the hood, or cylinder is connected with the exhaust tube. In the former plan the dust is drawn off the brush externally; in the latter the dust is sucked into the cylinder and drawn from it at its extremities. The plan more generally adopted is to cover the brush with a close-fitting hood, attaching this by means of a flexible tube to a vertical duct running overhead under the ceiling, or down under the floor, to the vacuum source.

The brush cover is a more important factor than is often supposed, inasmuch as any leakage at the extremities or along the upper and lower lines of impact will inevitably reduce the force of the vacuum, and deplete the efficiency of the whole apparatus. Already difficulties have arisen in this respect and the appliance as a whole blamed for want of attention to such a minor detail as the closure of the hood. The main objective lies in concentrating the extracting power of the vacuum on every square inch of the brush periphery, so that there shall be a draught, as uniform as possible, from end to end of the brush. Another important consideration arises here. The brush formerly used, that is, without cover or appurtenance of any kind, weighed from 48 to 56 pounds, each man bearing from one carding-engine to another a burden of 24 to 28 pounds. Then the addition of a cover weighing 8 to 12 pounds appreciably increased the daily labor of these workers.

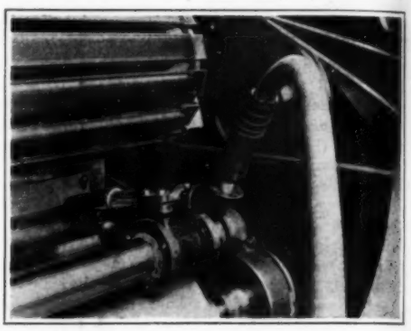
It was clear to machinists and operatives that density and weight in a stripping-brush are not indispensable factors, and that 60 pounds would furnish a reasonable maximum. Efforts have, however, been made to provide brushes and covers with a combined weight well



View in Carding Engine Room Fitted With Vacuum Strippers.

under 60 pounds. The central shafts are tubular; the driving-pulleys on the shaft are made of aluminium; this same metal is used for the extremities of the cover; so that machinists can now construct a brush and cover of less combined weight than the original brush alone. It is common enough to find the combination balancing 48 to 50 pounds; and there is no loss of efficiency in the reduced weight. As is reasonable to suppose, the workers fully appreciate the two-fold advantage of lighter appliances and riddance of dust.

The conveying pipes immediately proceeding from

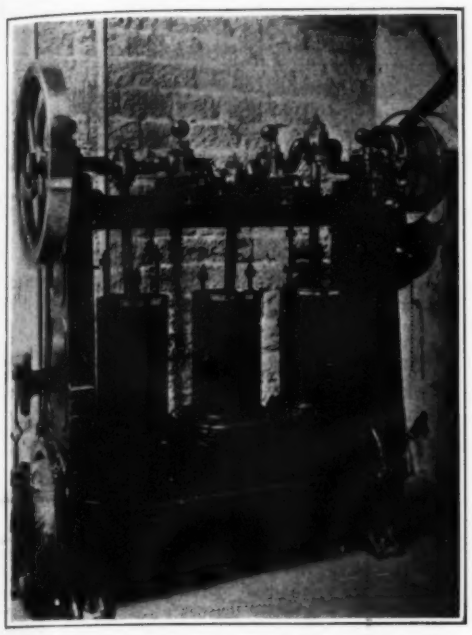


Near View, Showing the Flat Nozzle in Working Position.

the hoods are about 1½ inches in diameter. These are connected at the ceiling or under the floor, to horizontal ducts 2 inches in diameter, care being taken to link the vertical pipes with the ducts by curved joints. The curve is, of course, turned toward the source of the vacuum. Sharp corners, or right-angle joints are rigidly avoided, and every attempt is made to conduct the pipes along straight lines as far as is practicable.

Estimates have been made as to what strength of current is necessary for efficient stripping. Variations in the different forms of apparatus are, of course, inevitable; but it is generally held that, on an anemometric test, at least 50 cubic feet of air per minute should pass through the flexible tube on each carding-engine when the stripping process is in action. And since the vacuum to be created bears a direct reference to this amount of air-change considerable inventiveness has been displayed in constructing vacuum chambers. If the vacuum created is excessive and the air-current in the tubes too energetic, it will draw along with the useless, injurious dust a quantity of valuable fiber which is otherwise collected on the stripping-brush, detached by a hand-scrub, and used for waste-spinning. This would entail a considerable loss on the manufacturer and annul much of the value of his appliance. His desire is to cast off superfluous material, not useful cotton fiber. On the other hand, if the vacuum is weak and the air-current tardy the revolving brush will force the dust under the cover and scatter it in the atmosphere of the room. The vacuum generator is, therefore, the supreme factor of the whole apparatus.

For this purpose vacuum pumps, with two or three cylinders, are in popular favor. They may be driven directly by an electric motor, or indirectly from the mill engine through the medium of a counter-shaft and driving-pulley. Where four to six carding-engines are under treatment at the same time, the 3-cylinder type may be regarded as a necessity, with a view to maintaining a working vacuum throughout the whole operation of stripping. If through lack of vacuum there is want of uniformity in exhaust at the machines, the material passing through will be surcharged with dust, or the strippers will have it cast upon them. With a three-cylinder pump working at regular speed under a boiler pressure of 70 to 75 pounds per square inch there should be no difficulty in attaining 15 inches of vacuum as registered by a Bourdon gage. It is common to reach 20 inches before the stripping process is commenced. If then three carding-engines be treated simultaneously the vacuum should not descend below 3 inches. Any further reduction materially hampers the suction in the ducts, and fails to draw off the dust as rapidly as it is evolved from the stripping-brush. When a two-cylinder pump is in operation with, say, 80 pounds boiler-pressure, it is possible to attain 24 inches of vacuum, and where two machines are under treatment the vacuum seldom falls below 7 inches. With this vacuum it is scarcely possible to observe any dust emitted from the machine. In other experimental tests it



Three-cylinder Vacuum Pump, With Dust Receiver Chamber.

has been found that when the vacuum falls below 2 inches it is of little or no value as a dust eliminator. The maximum efficiency is maintained where the vacuum ranges between 5 and 10 inches. The extracting force thus generated is just sufficient to remove the fine dust without wrenching valuable fiber from the stripped cotton.

The pump makes its influence visible the moment the requisite vacuum is attained. Dust, lighter and heavier, is grasped by the current and hurried through the ducts to the generator, in which a strong canvas bag operates as receiver. This bag allows ordinary air to pass through its meshes but retains the dust which is emptied daily or three times a week as required. The amount of dust collected is surprising; here is the accumulation of injurious matter which would otherwise have been diffused in the air of the card room.

Where engine-power is at a high premium, and there is available vacuum in the air-pump, the ordinary vacuum pump is dispensed with and the ducts are connected with the engine air-pump on the back side of the piston. Here is a constant source of vacuum and with a double-acting prime mover there is no difficulty in attaining a vacuum of 20 to 25 inches. This is available at any moment whenever the operatives desire to strip the cards, and it retains its vitality when three or four machines are treated simultaneously. Here is a saving in the cost of installation of from 60 to 80 pounds, as all that is requisite in addition to the tubing is the receiver with its collecting-bag.

Dust-extractors for carding-engines are numbered by the dozen; and in several of these the employment of vacua plays an important part. One type embraces a steam ejector, an automatic steam-supply valve, and an air-tight chamber containing a coarsely-woven dust-bag. When steam is turned upon the apparatus it passes to the automatic valve and thence to the ejector, raising the vacuum, as indicated on the gage, to about 12 inches. Here the valve closes, shutting off the steam supply, and the available vacuum operates on the stripped carding-engines, two or three, as the case may be. When the vacuum falls to about 2 inches the valve automatically re-opens and allows a new influx of steam till, in a few seconds, the vacuum again reaches its maximum. The use of steam is thus practically confined to the actual period of stripping. In this system the vertical pipes are 1 inch in diameter and the horizontal ducts 1½ inches, all tubes being of drawn steel with smooth bore.

Another system adopts a vacuum pump of two or three cylinders in which a vacuum of about 24 inches is obtainable. The pump contains a receiving-chamber for the dust, this being sucked into a canvas bag which retains the dust but allows clear air to pass through. At convenient intervals the chamber door is released and the bag withdrawn for clearance. The "stripping dust" and the "stripped fiber" present a marked contrast. The vertical pipes are 1¼ inches in diameter and the ceiling pipes 2 inches. The brush cover is provided with aluminium ends and bushes, and bears a flexible tube for attachment to the vertical pipe. When the flexible tube is connected, the valve on this pipe is opened by hand, and the vacuum at once begins to operate.

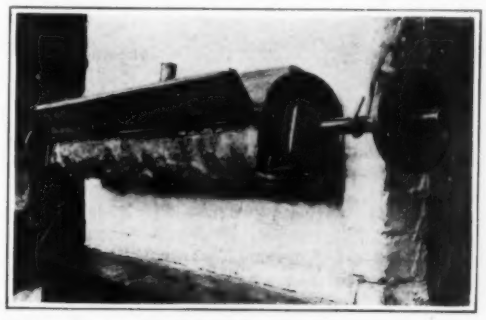
Still another system adopts vertical pipes of 1 inch diameter and ceiling ducts of 1½ inches. The vacuum is created by steam injection, the live steam at high pressure being brought directly in contact with the stripping-dust in the injector chamber. This dust and steam, in the form of sludge, is then passed into a copper funnel and falls through the inverted apex into a basin or other convenient receptacle. Surplus steam is emitted from the upper part of the funnel.

In the foregoing types dust is eliminated, and the

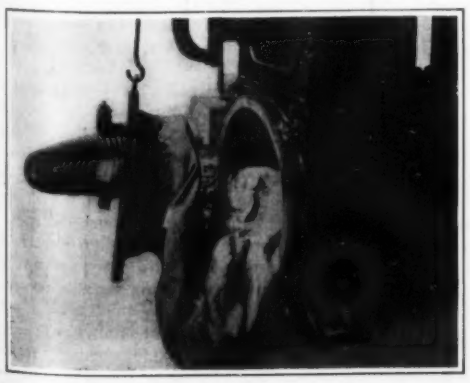
One Type of Dust Collector.

short-fibered cotton stripped from the carding and doffer cylinders is retained on the stripping-brush to be removed by the stripper himself with a hand scraper. There is another class of machines, in which a different method is adopted. A vacuum is created by means of a vacuum pump and transmitted by overhead pipes and flexible tubes directly to the card cylinders without the intermediary of a stripping-brush. For the purpose of stripping the main cylinder of the carding-engine a slot is made in the back plate. In this slot, and at close proximity to the card-wire, a nozzle is propelled from side to side by a traversing screw, the nozzle being attached to a flexible suction-tube. Hence, the vacuum created in the pump extracts from the wire fillet on the card cylinder both *dust* and short-fiber *stripping* in one operation. This product is then carried through the pipe-lines to a receiving-chamber where cotton fiber and dust are separated by filtration. The nozzle will travel across the machine once or several times at the bidding of a clutch placed in gear by the workman in charge. For stripping the doffer a separate nozzle and traversing-motion is provided. The nozzle is fitted over the wire fillet at a suitable gage, and travels from side to side two or three times as required.

In the general cleaning of machinery, irrespective of the stripping process on cards, it will be obvious that all these vacuum systems may be of considerable value. It only remains to fix sufficient length of flexible tubing to the vertical suction-pipes, and the extracting power of the vacuum may be employed for removing loose "fly" from machinery, walls, ceilings, beams, girders, flooring or any other place.



The Stripping Brush and Its Inclosing Metal Hood.



Canvas Dust-bag Partly Withdrawn from Vacuum Pump.

Potash, Silica and Alumina from Feldspar*

By Edward Hart

In a study of the commercial utilization of feldspar, which I undertook several years ago, it soon became evident that the potash alone would not pay the cost of extraction. This is the cause of the commercial failure of all the methods heretofore proposed. It is necessary, therefore, to separate and put into marketable form the other constituents—silica and alumina—if our method is to be successful.

The feldspar chosen should contain not much less than 12 per cent potash. Spar of this quality can be obtained in quantity, but one of the pitfalls inventors must avoid is the expectation of getting spar containing the theoretical 16.9 per cent of potash. The spar mixed with the proper amount of potassium sulphate and carbon is fused. The carbon added is so regulated that the resulting slag contains a considerable proportion of sulphids. This has the double advantage of saving a part of the sulphur, disengaged as hydrogen sulphid on dissolving in acids, which aids also in the complete decomposition by breaking apart the particles as it is given off. Experiments show that if a colorless slag is obtained of even higher alkali content it is much less easily decomposed by acid.

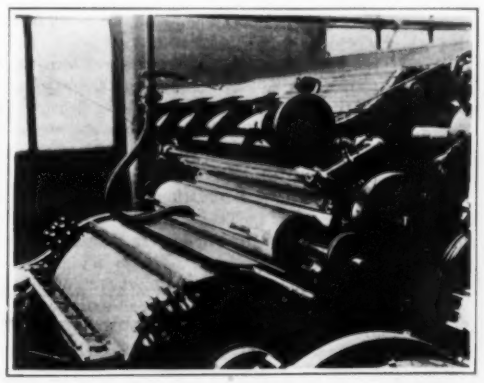
The slag so obtained must be very finely pulverized and treated in closed vessels with dilute sulphuric acid leaving behind a very pure silica which only needs washing and ignition to yield a marketable product for the potter's use or for making sodium silicate.

The solution contains potash alum and any small amounts of other metals such as iron, manganese and soda as sulphates. Lime is inadmissible, as the sulphate forms crusts on evaporating.

The solution on cooling gives at once crystals of alum, which washing with a little water and centrifuging renders marketable. Any iron present remains as ferrous sulphate in the mother liquor. Alum, however, is marketable only in limited quantity and must be for the most part, converted into its constituents, aluminium and potassium sulphates. This is easily done by adding to the solution in a closed vessel potassium sulphid in slight excess when aluminium hydroxid mixed with a little sulphur precipitates in a form easily washed. This is dissolved in hot sulphuric acid, run through a filter and allowed to solidify. The potassium sulphate is obtained by evaporation.

Each ton of feldspar (12 per cent K_2O) should yield 444 pounds K_2SO_4, 2,040 pounds commercial aluminium sulphate (18 per cent Al_2O_3), 1,300 pounds SiO_2.

* Paper read before the Eighth International Congress of Applied Chemistry.



The Vacuum Stripper Applied to the Main Cylinder of a Carding Engine.

Electrolysis from Stray Currents—III*

Damage Caused to Underground Structures

By Albert F. Ganz, M. E., Professor of Electrical Engineering, Stevens Institute of Technology

Continued from SCIENTIFIC AMERICAN SUPPLEMENT No. 1917, Page 201, September 28, 1912

CORROSION NOT CAUSED BY ELECTROLYSIS.

While electrolysis is undoubtedly responsible for much destruction of underground piping and other underground metallic structures, the author has frequently been asked to examine cases where the destruction had clearly not been produced by electrolysis from stray currents, but by altogether different causes. It must be remembered that corrosion of a metal from electrolysis can only occur where current leaves the metal to pass to an electrolyte such as damp soil. Service pipes have sometimes been found destroyed inside of cellar walls where they were not in contact with an electrolyte; the corrosion here is purely of a chemical nature, and not in any way chargeable to stray current electrolysis. Brass and copper pipes and fittings and condenser tubes in contact with salt water, also corrode quite generally, but this is caused by electrochemical action of the salt or contaminated water upon the metal, and not by electrolysis from stray currents. In some cases steel in reinforced concrete construction has also been found to be corroded, and the author has had occasion to investigate one important case where the steel reinforcement of a reinforced concrete building had been badly corroded, and where electrolysis from stray railway currents was claimed to be the cause of the corrosion. The construction however was such that there was no possibility of stray railway currents having passed from the steel to the surrounding concrete, which would be an absolutely essential requirement for the destruction by electrolysis, and the case was a clear one of corrosion from ordinary chemical causes. It is, therefore, wise where doubt exists to make a careful examination and determine positively whether or not a given case of corrosion was caused by stray current electrolysis.

REMEDIAL MEASURES.

There is only one complete remedy for electrolysis, and that is the use of a completely insulated return circuit. Such railways may be provided with double overhead trolley wires, as used for example in Washinton, D. C., Cincinnati and Havana; or with an insulated outgoing and return conductor in underground conduits, as used for example on the surface lines on Manhattan Island; or with separate insulated third and fourth rails for the outgoing and return current, as is used on the Metropolitan District Railway in London. With these systems the running tracks are not used as a part of the electric circuit, and as both positive and negative sides of the circuit are insulated no stray currents are produced.

Where a road operates on a private right-of-way, the rails can often be practically insulated from ground and the escape of current from the tracks prevented. For surface roads this can be practically accomplished by placing the rails on wooden ties above ground and using broken stone for ballast and keeping the rails out of contact with ground. In the case of railway lines operating on elevated structures the rails can be fastened to wooden ties and kept out of contact with the structure. These rails, supplemented where necessary with negative feeder cables, also insulated from the structure, can then be used for the return conductors. In this way the return circuit is quite thoroughly insulated from the elevated structure and from ground and stray currents.

A number or remedial measures, intended to reduce stray currents from electric railways using the grounded rails for a return conductor, have been tried. These methods may be divided into two classes, the first class aiming to remove the current harmlessly from pipes by metallic connections or bonds between the pipes and the railway return circuit, and the second aiming to minimize stray currents through ground.

Since stray currents cause damage only where they leave pipes to flow to the surrounding soil, attempts are frequently made to prevent destruction from electrolysis by connecting or bonding the pipes or other structures by means of metallic conductors to the rails or to the negative return circuit, so as to remove the electric current by metallic conduction and thus prevent corrosion from electrolysis. This method can protect lead cable sheaths because they form continuous electrical conductors, but it is not generally applicable to underground piping systems, because the latter do not form continuous electrical conductors, but are more or less discontinuous networks. While lead calked joints usually have a relatively low resistance, it frequently happens that they develop such high resistances as to make them practically insulating joints, due undoubtedly to the formation of oxide coatings. Cement joints and cement pipes have such a high resistance compared with iron pipes that they are practically insulating. Bonding of pipes to the rails or to the negative return circuit can only afford local protection to the extent that the piping connected forms a continuous metallic conductor, and this latter is an unknown and indeterminate quantity in a piping network. In the practical working out of a bonding or drainage system two opposing tendencies develop, first, there is a reduction in the difference of potential between pipes and rails in the positive areas, and consequent reduction of damage in these areas; and second, there is an increase of current flow on the pipes throughout the entire system, thus increasing the danger of trouble at high resistance joints, or other places where two piping systems or separate portions of the same system are electrically discontinuous. As a rule, in the early stages of this system and especially in small networks when there are comparatively few bond connections, and the resistances of the paths over the pipes are therefore relatively high, the effect is apt to be beneficial, reducing the danger in positive areas more than it increases the danger elsewhere. As the system grows and the load increases, more and heavier bonds become necessary. The current on the pipes may finally become so great that the trouble from current shunting around joints or between separate systems will increase more rapidly than the danger in the positive areas is reduced, and any further increase in the bonding becomes an actual source of danger to the system. Since bonding transfers the trouble from the region where it was most evident to a new locality where it may require several years to manifest itself, the false impression is created that the trouble has been removed. It is due largely to this obscure manner in which trouble develops that has caused this method to become quite

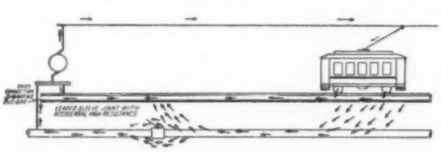


Fig. 12.—Diagram Showing Increased Danger from Electrolysis from Bonding Pipe to Rails Caused by Accidental High Resistance Joint in Pipe.

widely used. A number of cases have in fact been reported where a main bonded to the negative return circuit at the power station was completely destroyed by electrolysis a block or two away because of a high-resistance joint in the main, forcing current to shunt around the joint and leave the main a short distance away from the power station. In one of these cases one entire block of main had to be replaced. This case is illustrated in Fig. 12. In another case, the water main on one side of the street was bonded to the negative return circuit at the power station, and a main on the opposite side of the same street, although connected through cross-piping to the bonded main, was completely destroyed because high-resistance joints had developed in the connecting pipes. In addition, bonding pipes as a means of protection always render the bonded structures a part of the negative return circuit, and, therefor, are a source of danger to other underground structures which are not bonded. It has in fact been frequently found that where gas or water-service pipes cross bonded cable sheaths, currents are induced to flow from the service pipes to the cable sheaths, and produce gradual destruction of the service pipes. A case of this kind was illustrated in Fig. 11. In the case of one city, nineteen service pipes were destroyed in the course of one year directly where these pipes cross telephone ducts containing cables whose sheaths were bonded to the railway return circuit. One engineer who has studied this problem very carefully and entirely impartially has very aptly likened bonding to the drug habit, producing temporary relief at the expense of permanent and perhaps irreparable injury to the victim, which injury is, however, too rarely attributed to the true cause.

Among the methods which have been used to minimize the escape of currents on systems using the grounded rails for the return conductors are increasing the resistance between rails and ground, increasing the resistance between pipes and ground, increasing the resistance along the line of the pipe by means of high-resistance joints, and decreasing the drop in potential in the grounded rails.

The resistance between rails and ground can often be increased by using broken stone ballast, whereby the rails are kept out of contact with ground, and water is allowed to trickle away from the rails thereby maintaining high resistance between the rails and ground. Where an electric railway owns its own right-of-way, it is frequently feasible as already stated to practically insulate the rails from ground.

Attempts have been made to insulate pipes from ground by paints, dips, and insulating coverings. Experience as well as a large number of tests on such paints and dips have however shown that no dip or paint will protect a pipe against electrolysis in wet soil. The first difficulty is the mechanical one of applying the paint so as to form an absolutely perfect coating, and then to prevent mechanical damage to the coating. Where imperfections exist or develop aggravated trouble always ensues. Experience further shows that even where paints or dips are apparently intact and perfect, electrolytic action is not prevented, and in fact very serious electrolytic pittings have been found under apparently good coatings. It has been found that in most cases the coatings applied have been either completely destroyed by the effects of the wet soil and the electric currents, or defects in the coating have developed causing concentrated corrosion at such defective spots. The destruction of paints in wet soil where subjected to an electric current is due to traces of moisture finding their way through the coating, giving rise to the flow of a feeble current and resulting in a very slight amount of electrolysis. The gases and other products of electrolysis then form blisters and finally rupture the coating. Pipes in positive districts coated with imperfect insulating coatings are in greater danger from electrolysis than bare pipes. Coating pipes in negative districts with insulating covering does some good in reducing the amount of stray current which reaches the pipes. Where it is attempted to apply a heated material, like pitch or asphaltum, to a cold pipe, it is impossible to completely cover the pipe. The only kind of insulating covering which appears to afford certain protection is a layer of at least one or two inches of a material like coal tar, pitch or asphaltum, of such a grade that it is not brittle and so will not crack, but yet is hard enough to remain in place. The best way to apply such a layer is to surround the pipe with a wooden box, support the pipe upon creosoted blocks of wood or upon blocks of glass, and then fill the space between the box and pipe with the molten material. As a further protection an insulated coupling should be introduced at each end of the section covered so that even if the covering should become defective at any point or points no current can reach these points to corrode them by electrolysis. A pipe treated in this way with the work done so as to be mechanically perfect would undoubtedly be protected from electrolysis. However, the cost of carrying out such an installation is absolutely prohibitive, except in a few cases, such as in the case of service pipes in very bad localities or in the case of some very important individual pipe line of small size. It is not sufficient to apply the covering only in the positive district, nor on the other hand, is it always necessary to cover the entire length of line. The portions which must be insulated can only be determined by properly conducted electrical tests. Experience has also shown that embedding a pipe in cement or concrete, even if this is several inches in thickness, does not protect the pipe from electrolysis, and in some cases it has even been found that the pipe in concrete is destroyed at least as rapidly as when it is buried in ground.

Current flow on pipe lines can also be practically prevented by using insulating joints for every joint. Cement joints as ordinarily made do not generally produce metallic connection between the two pipes and may practically be classed with insulating joints. The cause of the high resistance of cement joints is probably due to the fact that although every attempt is made to push the spigot end home into the bell when laying cast-iron pipe, as a matter of fact in most cases the two pipes are not in metallic contact. Even where there is metallic contact this is probably over a comparatively small area, if not at a point. As the end of the spigot is always heavily coated with scale, such metallic contact generally forms a poor electrical connection of comparatively high resistance. It is a simple matter to positively prevent metallic contact by inserting a ring of some cheap insulating

* A lecture delivered before the American Water Works Association at Louisville, Ky., June 6th, 1912.

material such as fiber or cardboard between the end of the spigot and the interior of the bell, and this has been done in some cases. The resistance of cement joints is then the electrical resistance of the cement intervening between the spigot and bell, and while cement is not an insulator but on the contrary is probably as good a conductor as ordinary ground, yet compared with iron the resistance is so high that the cement joints practically interrupt the electrical continuity of the pipe line. A pipe line laid with all cement joints or with all insulating joints is, therefore, a discontinuous electrical conductor and is not capable of carrying stray electric currents. Such a pipe line cannot, therefore, pick up current in an extensive negative area to discharge it in a restricted positive area, which is generally the cause of the most serious electrolytic danger. For this reason a piping system with all cement or insulating joints is on the whole much less likely to be affected by electrolysis than a piping system with all lead or screw coupling joints. Experience has shown however that a cement-jointed piping system is by no means immune from electrolysis, and there is abundant experience which shows that cement-jointed mains and especially service pipes from such mains can suffer severely from electrolysis. In these cases the stray currents reach the mains and service pipes from other pipes or by other paths. An example of a gas service pipe from a cement-jointed main destroyed by electrolysis from stray currents which reached the gas-service pipe from the water piping is illustrated in Fig. 11.

(To be continued.)

Phosphorus and Its Compounds

By Edwy Godwin Clayton, F.C.S., F.I.C.

PARTICULARLY important just now are the problems connected with the constitution of the igniting mixtures used for the heads of matches. Therefore, the following account of the principal varieties and derivatives of phosphorus, which have been used or proposed to be used in the match industry, is with much respect submitted to the congress by the writer, together with some remarks upon the relative suitabilities of these products for the purpose, and a few suggestions regarding the characters to be sought in the ideal igniting substance for the match of the future.

From the date of Sauria's invention of the phosphorus friction match (1831) until six years ago, ordinary white or yellow phosphorus was pre-eminently the combustible body for match heads; but Loriser and other investigators, from 1845 onward, pointed to the dangers attending its use; and since 1906 in most European countries this has been forbidden. Some countries (Denmark and Switzerland for instance) even earlier prohibited the manufacture of matches with white phosphorus in the compositions. Great Britain adopted prohibition in 1908 (8 Ed. VII, 1908, ch. 42); and there can be little doubt that eventually every country in Europe will follow suit. This is, for the sake of the workers in match factories earnestly to be wished. United States also has formed a way to put a stop to the use of white phosphorus in the manufacture of matches by a prohibition tax placed upon their production after July 1st, 1913. The horrors of the phosphorus disease, matchmakers' necrosis, or "phossy jaw," as it used to be called by the British operatives, have caused an incalculable amount of suffering; and we, of whatever race, owe it to our account with coming generations that in our time we should have stamped out the evil in every part of the civilized world.

White phosphorus was in early days thought to be as unmanageable as a man-eating tiger. Mixtures with diluents such as magnesia (Derepas, 1809) were kept in flasks or phials and withdrawn in small quantities at a time, upon splints, which were then ignited by friction. Later, after Sauria and his successors had shown how easily white phosphorus friction matches could be made, and after these products had long been in general use, the grave difficulty of necrosis presented itself: a difficulty yet being grappled with in countries where the use of ordinary phosphorus has not been discontinued. The striking parts of the heads of double-tip matches are stated unfortunately to contain extremely large proportions of white or yellow phosphorus; and it should be the aim of every maker to produce similarly excellent matches free from a particle of this risk-laden ingredient.

The dark red, or so called "amorphous," variety of phosphorus, discovered by v. Schröter (1845), but, it would seem, previously tried by Pasch (1844), in the belief that he was working with an oxide, and during the fifties unsuccessfully essayed in strike-anywhere matches by British, French, and Austrian manufacturers, came chiefly to be used as is well-known, in the rubbing surfaces or rubbers, on the boxes of safety-matches. The last-named, by the way, have greatly increased in popularity of late years in Great Britain. The difficulties attending the employment of amorphous phosphorus in the heads of strike-anywhere matches have of late years been overcome to a considerable extent. The writer has not only examined good matches of Continental manufacture, with dark red phosphorus in the friction-heads, but has himself succeeded in making practicable red phosphorus strike-anywhere matches of quite presentable quality. The perils of mixing and milling match-compositions containing red phosphorus have for many years been unduly magnified, not to say exaggerated; and it is possible to prepare without danger mixtures containing reasonably small proportions of red phosphorus, which in the match heads will not ignite explosively, nor burn with fierceness and irregularity. Dark red phosphorus, when reasonably pure, is non-toxic, gives off no vapor or "fume," even at temperatures far above ordinary working and living conditions, and the temperatures required to ignite match compositions containing it are considerably higher than those which cause the "firing" of white phosphorus compositions. The disadvantages of dark red phosphorus are its high price, and a tendency, shown in many commercial samples, to take up moisture and undergo partial oxidation. Many ways of "taming" amorphous phosphorus have been tried; the efforts have been in the directions of rendering less violent its reaction with potassium chlorate of modifying the temperature of its ignition, of rendering the material less hygroscopic, and of making it safer to handle in the factory. Mixtures of red phosphorus with zinc powder, sulphur, chalk, paraffin wax, zinc oxide and chalk together, borates and phosphates, or with flour and cork-dust, have been used by various inventors; boiling with aqueous solutions of metallic salts, and distillation, followed by filtration (for the removal of acidity, etc.) have also been suggested. The Schwiening method of introducing calcium plumbate into a match composition containing red phosphorus, potassium chlorate, and other ordinary constituents, was in 1907 adopted in Germany, with some success, though the matches so made have not been free from severe criticism. It is contended that the calcium salt, in decomposing, produces lead peroxide, neutralizes the acid products of oxidation, and regulates the combustion.

The so-called "neutral amorphous phosphorus" of Caussemille Jeune et Cie and Roche et Cie (1909) is prepared by "treating by distillation and filtration ordinary amorphous phosphorus which has previously been well washed." These processes remove small quantities of white phosphorus, oxy-acids of phosphorus, or alkaline bases, if present; the product is stated to be without any basic or acidic reaction; and the use of such a preparation may undoubtedly diminish the risk of formation of hygroscopic compounds in a red phosphorus match composition.

Other varieties or derivatives of the element phosphorus are of different shades of red, from orange-tinted to scarlet, insoluble in carbon disulphide, just as is dark red phosphorus, more chemically active than the last-named inflammable in some instances at lower temperatures, and, so far as we know, non-poisonous.

The only one of these light red products known to the writer to be used in Great Britain is "Scarlet Phosphorus," or "bright red phosphorus," $(P_4)_2$ (?), discovered by Schenck (1903), but products of somewhat duller tints, similar to those obtained by Boesekeen's (1907) and Zecchini's (1907) methods, are, it is believed, considerably used abroad.

Scarlet phosphorus is employed, in the United Kingdom, for the production of strike-anywhere or "parlor" matches, but not to a very large extent; and, although it yields very good matches, these, in the opinion of friends of the writer who are match manufacturers, strike less freely and yield more smoke than matches made with tetraphosphorus trisulphide, one of the class of compounds and derivatives next to be described, namely, the sulphides of phosphorus. Faraday (1818) was one of the first to prepare any of these bodies; Berzelius and later observers worked at the subject throughout the nineteenth century; in 1823 small quantities of sulphur and phosphorus, carefully fused together, were supplied in phials, in conjunction with sulphur-tipped splints, by which some of the mixture was withdrawn, to be kindled by friction; Puscher (1869) proposed without avail the use in match heads of sulphide of phosphorus instead of phosphorus: Bals (1896) suggested the employment of a fused mixture of the sulphur and red phosphorus: and finally, an examination of tetraphosphorus trisulphide, discovered by Lemoine (1864) led Sévène and Cahen to adopt this compound in the manufacture of French matches (Ger. and Eng. patents, 1898).

More than a dozen compounds of phosphorus and sulphur have been described or mentioned by Faraday, Berzelius, Böttger, Mitscherlich, and later investigators —P_4S (Berzelius, 1843); P_2S (Faraday, 1818, Berzelius, 1843); P_2S (Berzelius); tetraphosphorus trisulphide, P_4S_3 (Lemoine); P_2S_3 (Serullas), P_3S_5, P_2S_4, or PS_2 (Seiler); pentasulphide, P_4S_{10} (Berzelius); P_4S_5 and P_4S_7 (Mai); P_2S_{11} (Dervin); P_2S_5 (Boulouch); PS_6 (Berzelius); and P_2S_6 (Stock and others); Helff (1893) considered that the existence of four of these compounds had been proved; P_4S_6; P_4S_7; P_2S_6 and P_2S_9. But Stock and v. Bezold (1908), and, corroboratively, Mai (1911), conclude that the existence of only three sulphides of phosphorus have been established: namely, tetraphosphorus trisulphide, P_4S_3, tetraphosphorus heptasulphide, P_4S_7, and tetraphosphorus decasulphide, P_4S_{10}. The trisulphide or so-called "sesquisulphide," is the chief phosphorus derivative applied at the present time in Great Britain to the manufacture of strike-anywhere matches. It is extensively used in Sweden and elsewhere on the Continent of Europe: exclusively in France: and very largely indeed in the United States of America. Non-toxic, pale yellow, soluble in carbon disulphide, inflammable at about the temperature of boiling water, readily workable in match compositions, yielding mixtures which do not give off injurious vapors during the manufacturing operations, and moderate in price, sesquisulphide of phosphorus has proved itself a useful and satisfactory substitute for the deadly phosphorus. The matches, if in a trifling degree less sensitive to friction than the white phosphorus products, are as good as can reasonably be desired; and their manufacture is at least humane.

Other preparations of phosphorus and sulphur containing the elements in proportions different from those in sesquisulphide have been suggested or tried in Europe, such as the products described by Wheelwright (1902), combinations of phosphorus with sulphur the phosphorus being in excess of that present in tetraphosphorus trisulphide; Johnson, for the Chemische Fabrik Griesheim-Elektron (1902), compounds stated to be the trisulphide P_2S_3, hexasulphide P_2S_6, and pentasulphide P_2S_5, with the addition of zinc oxide to prevent the evolution of sulphuretted hydrogen from the wet match-composition; Huch (1903), a preparation of sulphur and phosphorus obtained by treating red phosphorus with sulphur chloride, or with a solution of sulphur in the chloride; and Stahl and Nölke (1910), P_4S_{10}, prepared by heating to the fusing point a mixture of P_4S_3 with sulphur and described as separating from its solution in carbon disulphite in the form of yellowish plates. This body melts at 52 deg. Cent., and at 128 deg. to 130 deg. Cent. is converted into P_2S_5, insoluble in carbon disulphide.

Besides the foregoing sulphur-phosphorus preparations and very closely related to some of them, several compounds containing or consisting of metallic thiophosphites, hypothiophosphites, and pyrothiophosphites, have been introduced for match manufacturers' use: such as the Griesheim-Elektron Company's "sulfophosphit" (1902) a thiosulphite or hypothiosulphite preparation, in which are very intimately associated together sulphur, zinc, and phosphorus, stated to be obtained by uniting red phosphorus, sulphur, and metallic sulphites, in the required proportions: the product of Gartenmeister (1908) consisting of the pyrothiophosphite of antimony or other heavy metal; and Staier's compound (1912), made by heating red phosphorus, sulphur chloride, and a metallic sulphide to 65 deg. Cent.

Oxygen compounds of phosphorus have also been tried. In the year 1898, Bohy, Gallay and Company proposed the use of metallic hypophosphites, such as the calcium salt in conjunction with bichromate of potassium and barium chromate; and the writer during the following year made on a fairly large experimental scale some quite good matches containing calcium hypophosphite in association with chromic acid.

The agent of the before-mentioned Greisheim-Elektron Company in 1903 patented a substance claimed to be phosphorus suboxide, P_4O. Whether the existence of a definite compound represented by this formula has yet been established, is, however, a debatable question, which Chapman, Lidbury, and Burgess (1899-1901) have answered in the negative, though Michaelis and v. Arend (1902) dispute their conclusion. Hydrides of phosphorus have not been forgotten, and have yielded encouraging results. Wheelwright (1906) proposed the use of solid phosphorus hydride (P_4H_2) or $P_{12}H_6$ and Castiglione (1907) followed suit. Later (1909), Wheelwright recommended the hydride P_3H_2, an orange red product obtained from $P_{12}H_6$ by the action of sunlight, or by exposure to a temperature of about 175 deg. Cent. Many trials have been made with metallic phosphides, but the results obtained by the writer were not promising.

* Paper read before the Eighth International Congress of Applied Chemistry.

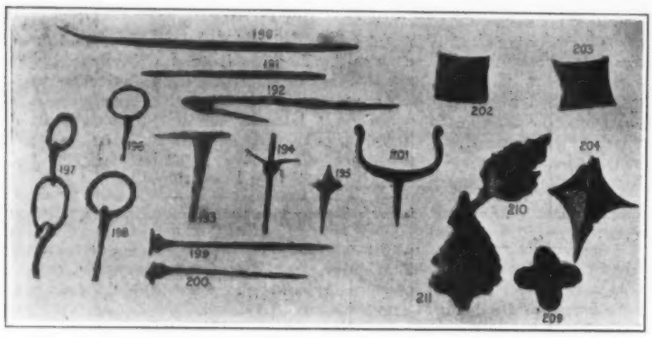


Fig. 1.—Various Iron Objects. Note Especially the Pens (Stylus), Specimens 199 and 200.

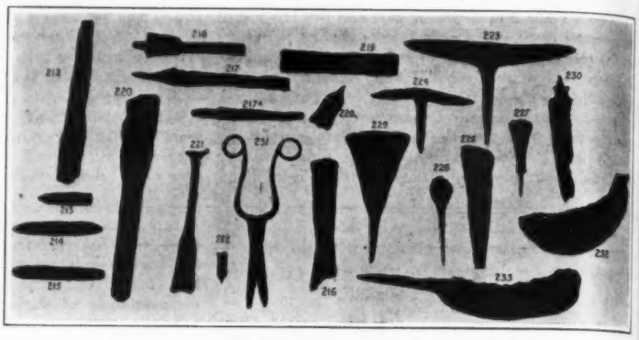


Fig. 2.—A Number of Cutting Tools for Various Uses, Including a Pair of Scissors, Specimen 231.

Sinhalese Iron and Steel of Ancient Origin—I*

Beginnings of the Iron Age

By Sir Robert Hadfield, F.R.S., Sheffield

Introduction.

The use of iron, including in this term the combination of iron and carbon known as steel, such as produced by the fusion or cementation processes, has without doubt existed from a time dating back to a very early period in the world's recorded history.

Owing, however, to the avidity of the oxygen present in the air for this metal, it has been most difficult to obtain ancient specimens of iron. We have, therefore, but little definite evidence regarding its early manufacture and use. It is for this reason the author thought that the present description of some interesting Sinhalese† specimens of this nature which came under his notice during a recent tour in the East would be of interest to the members of the Institute.

We who live in this modern Western world are apt to pride ourselves that we have all the knowledge on this subject of metallurgy, but the facts presented in this paper show this assumption to be incorrect. While information available from the East regarding iron of ancient production is fragmentary, yet undoubtedly a comparatively high state of metallurgical art and knowledge must have prevailed, not only centuries, but more than a thousand years ago.

The author has taken advantage of the opportunity afforded to make what he hopes will prove an addition to our knowledge, and trusts the information submitted will prove to be of interest.

This is not the first paper which has been read on this subject. One hundred and seventeen years ago—to be exact, on June 11th, 1795, Dr. George Pearson, a Fellow of the Royal Society, read a paper entitled "Experiments and Observations to Investigate the Nature of a Kind of Steel Manufactured at Bombay, and there called 'Wootz,' with Remarks on the Properties and Composition of the Different States of Iron."

The author is greatly indebted to the Royal Society for permission to make use of Dr. Pearson's paper, as well as of his own paper recently communicated to that Society.

It was the author's good fortune during his recent tour round the world to visit the Colombo Museum and inspect a set of ancient specimens of iron and steel which were obtained from some of the buried cities of Ceylon. These cities date back from about 500 B. C., and since then have had a more or less continuous history as habitable by human beings; the history of some of them continued up to about 1500 A. D.

This collection, which was formed quite recently, and has not been previously known or described, was lighted upon quite by chance, and was the find of an otherwise idle day. It is a fascinating collection of ancient specimens and instruments of iron, and is in many respects absolutely unique. The author met the then Director (April, 1910) of the Museum, Dr. Arthur Willey, F.R.S., and was afforded every facility for examination. Finally, through the kindness of his friend, His Excellency the Governor-General of Ceylon, Sir Henry McCallum, to whom grateful acknowledgment is here made, he was accorded the privilege of having placed at his disposal a few of the specimens for investigation. It seemed to the author that an account of the research carried out on these specimens might form an appropriate sequel to the interesting paper to the Royal Society by Dr. Pearson on "Wootz" steel a century ago. The author believes that the research which has been carried out yields information which has not previously been available on the subject of iron and steel specimens of known ancient origin; in fact, he has not been able to find in previous publications any complete and authentic analyses accompanied by

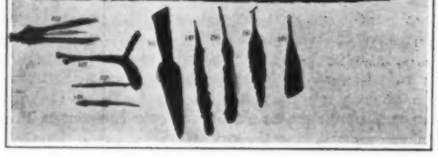


Fig. 3.—Arrow and Spear Heads and a Sword Blade.

mechanical tests and photo-micrographs showing the structure of such material.

Not only does the Colombo Museum contain this large number of interesting specimens of ancient tools and implements of various kinds, some 250 in number (these are shown in Figs. 1 to 7) but in another section of its exhibits are shown several swords of more modern date, bearing the dates of the years 1374 and 1416 A. D., with Sinhalese legends inscribed upon them.

To those interested in the metallurgy of iron and steel, this collection of ancient iron and steel specimens appeals as being without doubt the most complete and unique in the world. There is probably nothing at all like or approaching it in any other museum or private collection.

The following is Dr. Willey's description of the specimens sent to the author from the Colombo Museum for the purposes of this research:

1. Museum specimen, No. 138, steel chisel from Sigiriya, of the fifth century A. D., length 10 inches (Fig. 5).

2. Museum specimen, unnumbered, ancient nail (pointed end broken off), 13½ inches long, probably also

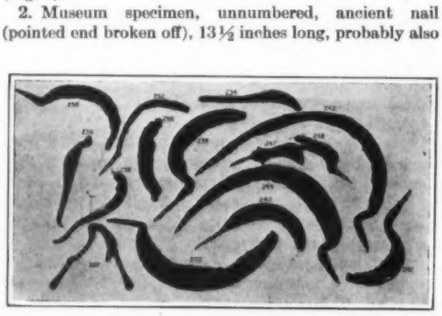


Fig. 4.—Areca Nut Cutters, Sickles and Reaping Knives.

from Sigiriya, of the same date as the chisel, but the particulars are lost. It is, however, certainly very ancient, and is typical of a special class of implements found in the ruined cities of Ceylon (Fig. 6).

3. Native bill-hook or "ketta," just as it came to hand from Dumbara, near Kandy, the headquarters of much mediæval native work (Fig. 7).

In this paper it has been attempted to deal only with specimens of iron of undoubted antiquity. With the modern manufacture of Sinhalese and Indian steels, it is undesirable to deal at the present time.

With this preface the author will now refer to the causes which led to his own investigations and research. While there is often an impression that the use of iron, including in this term the alloy of iron and carbon known as steel, is a modern development, this is probably incorrect, as without doubt such knowledge really dates back to the earliest stages of tradition. For several reasons, and, notably, owing to the avidity of iron for the oxygen present in the air, it has been difficult to obtain ancient specimens of this material, more particularly in the form of steel. It is for this reason that the Sinhalese specimens in question are so valuable, for there exists but little definite evidence as to the period when iron and steel were first employed by man.

There is a reference in the report of the Director of the Colombo Museum to the fact that iron implements are very liable to rust even in the atmosphere of Ceylon, with its constant high temperature, and even after having been cleaned and impregnated with paraffin-wax by Krefting's method. Rust preservatives are therefore used in the museum from time to time as rust appears.

One reason which caused the author as a metallurgist to be specially interested in these Sinhalese specimens was that during his tour in the East he first visited Egypt, and an inspection there of the wonderful works in stone raised questions in his mind as to the method and tools with which these memorials in stone were hewn to shape.

It has been asserted that the Egyptians knew how to harden copper, so that it could be made to take and keep a cutting edge under the severe working stresses to which the tool must have been subjected in order to produce the hundreds of thousands of forms now to be seen in the Nile Valley, from Cairo to Khartoum or beyond, over a distance of some 2,000 miles. Such work must have involved the labors of immense numbers of stone-masons, who would require tools. The author is strongly of opinion that no method of hardening copper was then known which would produce tools having a hard cutting edge, or which were at any rate at the same time tough enough to stand the severe impact blows such as stone-cutting work required. Copper alloyed with other elements can be hardened, as was recently evidenced in a paper read by Dr. Rosenhain and Mr. Lantsberry before the Institution of Mechanical Engineers. During the course of the discussion on the paper it was stated that a turning tool had been made which had cut iron. The author is of opinion, however, that such a material made up into chisels, wedges, and the like, would be of little value for hewing to shape and finishing the gigantic works in stone of the Egyptians.

It is far more probable that the ancient Egyptians were not only able to make steel for tools of all kinds, but also to cement and harden it, or, if they were not themselves steel-workers, they obtained the necessary material and help from the workmen of another nation. There is, indeed, evidence that such was the case, and the facts available suggest that in the art of steel-making Egypt received assistance from India or China. There are, it is true, but few specimens of iron and steel tools or implements in and from Egypt. There is, however, a scythe of iron in the British Museum; examination shows it to be in such an oxidized condition that it is not possible to

* Excerpts from a paper read before the Iron and Steel Institute, May 9, 1912, and published in *Engineering*.

† The term "Sinhalese" is explained as follows by Dr. S. M. Burrows, M.A., in his book, "Buried Cities of Ceylon": —"In B.C. 543, Wijiyo and his Sinhalese followers landed in Ceylon, possibly near the modern Puttalam, on the west coast. He is said to have been the discarded son of one of the petty princes in the valley of the Ganges, while the native chronicles explain the name of his race by tracing his paternity to a lion—'Sinha.'"

Fig. 5.—Ancient Chisel from Sigiriya (Fifth Century A. D.)

The portions shown broken away were removed as samples for analysis and other tests.

may definitely what is the nature of the material, although it is undoubtedly iron. This scythe, which the author has seen and handled, is so thin and corroded that it would almost fall to pieces unless most carefully dealt with. There is also an important specimen of iron taken from the Great Pyramid. In determining this general question as to the use of steel by the Egyptians, it should be remembered that there are several ways of endowing iron with the quality of hardening—that is, after heating and quenching it in water, or other cooling medium. The material ordinarily termed wrought iron can be made to acquire or take up carbon by cementation. This process is still largely carried out in Sheffield, principally upon bars, which are by these means carburized with required varying percentages of carbon. These bars are chiefly made for the purpose of afterward being melted in crucibles to produce the highest and purest qualities of steel. Such cemented steel, or "blister" steel, is in some cases directly worked up into tools having cutting edges, and is then termed "bar steel." This aspect of the case is referred to because even if ancient specimens of highly-carburized steel are not available, it must be remembered that wrought or forged iron itself can be cemented or carburized, or the edges of tools can be so treated.

There is reason to believe that this knowledge, although in a crude form, was possessed by ancient workers in iron. Such methods may probably be regarded, to a certain extent, as "case-hardening." In such process the surface of the material to be treated must have been placed in a gaseous medium, or in a medium of charcoal or other pure form of carbon, then heated, and the surface carburized to the desired extent and depth. Such material, when again heated and quenched, carried a cutting edge.

Somewhat singular to say, this knowledge appears to have been possessed and to be proved in an interesting manner by one of these Sinhalese specimens which the author has examined, namely, the chisel (Experiment No. 2,252), which is proved to have its edges cemented or carburized. Under the section devoted to the description of these experiments will be found full particulars of this remarkable chisel, together with photo-micrographs, analyses, and the results of mechanical and other physical tests.

The other and chief method of producing "cast steel"—that is, an alloy of metal with carbon varying from about 0.50 to 1.80 per cent—is, of course, by direct fusion of bar iron, or, in the case of a steely iron made in the manner just referred to, in a closed receptacle or "crucible." To accomplish this required a high technical knowledge, for it is not merely necessary to obtain the requisite quality of bar or melting iron, practically free from, or very low, in sulphur and phosphorus, but there has also to be solved the equally difficult problem of preparing a receptacle or crucible to withstand handling at the high temperature required to fuse the materials being melted, and also the intense heat to which it is subjected without itself fusing. It is interesting to observe that in the Colombo Museum clay crucibles (of modern manufacture, it is true) can be seen, but apparently the same method has long been known and practised in the East. Therefore our modern belief that such method originated in Europe is probably not correct.

As before mentioned, the specimens in the Colombo Museum were taken from the ruins of some of the buried cities of Ceylon, and in view of the importance of the collection, the author instructed Messrs. Plâté, the excellent photographers in Colombo, to prepare for him the photographs of these specimens which accompany this paper.

The names of the buried cities in question are: Anuradhapura, 437 B. C. to 769 A. D.; Polonnaruwa, 769 A. D. to 1319 A. D.; and Sigiriya, 479 A. D.

An interesting paper on the ruins of Sigiriya appears in the Royal Asiatic Society's Proceedings, vol. 8, 1876.

The articles in each photograph are numbered, and accompanied by a tabulated statement describing the specimens, also stating from which of the ruins of the buried cities in Ceylon they were taken. No less than about fifty different articles are comprised, including those of agricultural implements, cutting instruments, tools for building and other trades, warlike implements, and general articles.

While the Sinhalese temples and monuments are of much later date than those of Egypt, nevertheless, in view of the metallurgical knowledge which was evidently

Fig. 7.—Ancient Ketta or Billhook.

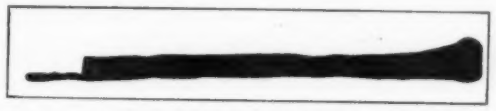


Fig. 6.—Ancient Nail, 13½ Inches in Length from Sigiriya (Fifth Century A. D.)

possessed at a very early period in India, and later in Ceylon, it is quite evident that the knowledge then prevailing in these matters must have been considerable. There is no evidence that the metallurgy of iron was understood in Egypt; it seems more than likely, therefore, that, as has been suggested by several authorities, aid was obtained by the Egyptians from the Far East—no doubt India or China, whence there was a constant stream of trade and commerce. They were thus enabled to carry out their many wonderful works in stone, including temples, pyramids, statues, obelisks, sarcophagi, sculptured walls, figures, tombs, steles, and the like, many of them prepared from the intensely hard Assouan granite, also red and black granite, quartz, porphyry, limestone, and sandstone. Some of the hieroglyphics have been found cut to a depth of no less than 2 inches. To carry out such work requires tools of excellent quality.

As will be seen by the examples in Figs. 1 to 4, there are several hundreds of these ancient iron specimens. They comprise large and small chisels, including stone-cutting chisels, about 2½ inches in length and ½ inch in diameter, axes, adzes, hoes, wedges, scissors, locks, keys, and many other articles. Regarding the age of these specimens, Dr. Willey, F.R.S., the then director of the Colombo Museum, states that this is vouched for by those thoroughly competent to make the statement, and that the specimens are 1,200 to 1,800 years old. They are in a remarkably good state of preservation, and many of them being quite bulky, offer much better scope for examination than anything of the kind the author has ever seen or heard of.

When considering the origin and nature of these specimens, it should be borne in mind that the "Veddas," the aboriginal hunting caste or hill tribe of Ceylon, were of very poor intellect, and it is extremely doubtful whether the high order of knowledge necessary to produce steel, and particularly steel by the crucible process, could have been possessed by them.

Ceylon is, however, from the ethnological point of view, practically an integral part of India. The distance between the two countries is so small that it is shortly to be spanned by rail. There seems, therefore, good grounds for the assumption that the requisite skill and knowledge required for steel-making probably reached Ceylon from India.

(To be continued.)

The Nature, Origin and Maintenance of Life

Inaugural Address of the President of the British Association for the Advancement of Science

By Prof. E. A. Schäfer, LL.D., D.Sc., M.D., F.R.S.

DEFINITION.

EVERYBODY knows, or thinks he knows, what life is; at least, we are all acquainted with its ordinary, obvious manifestations. It would, therefore, seem that it should not be difficult to find an exact definition. The quest has nevertheless baffled the most acute thinkers. Herbert Spencer devoted two chapters of his "Principles of Biology" to the discussion of the attempts at definition which had up to that date been proposed, and himself suggested another. But at the end of it all he is constrained to admit that no expression had been found which would embrace all the known manifestations of animate, and at the same time exclude those of admittedly inanimate, objects.

The ordinary dictionary definition of life is "the state of living." Dastre, following Claude Bernard, defines it as "the sum total of the phenomena common to all living beings." Both of these definitions are, however, of the same character as Sydney Smith's definition of an archdeacon as "a person who performs archidiaconal functions." I am not myself proposing to take up your time by attempting to grapple with a task which has proved too great for the intellectual giants of philosophy, and I have the less disposition to do so because recent advances in knowledge have suggested the probability that the dividing line between animate and inanimate matter is less sharp than it has hitherto been regarded, so that the difficulty of finding an inclusive definition is correspondingly increased.

LIFE NOT IDENTICAL WITH SOUL.

As a mere word "life" is interesting in the fact that it is one of those abstract terms which has no direct antithesis; although probably most persons would regard "death" in that light. A little consideration will show that this is not the case. "Death" implies the pre-existence of "life"; there are physiological grounds for regarding death as a phenomenon of life—it is the completion, the last act of life. We cannot speak of a non-living object as *possessing* death in the sense that we speak of a living object as *possessing* life. The adjective "dead" is, it is true, applied in a popular sense antithetically to objects which have never possessed life; as in the proverbial expression "as dead as a door-nail." But in the strict sense such application is not justifiable, since the use of the terms dead and living implies either in the past or in the present the possession of the recognized properties of living matter. On the other hand, the expressions *living* and *lifeless*, *animate* and *inanimate*, furnish terms which are undoubtedly antithetical. Strictly and literally, the words animate and inanimate express the presence or absence of "soul"; and not infrequently we find the terms "life" and "soul" erroneously employed as if identical. But it is scarcely necessary to state that the remarks I have to make regarding "life" must not be taken to apply to the conception to which the word "soul" is attached.

PROBLEMS OF LIFE ARE PROBLEMS OF MATTER.

The fact that the formation of such a conception is only possible in connection with life, and that the growth and elaboration of the conception has only been possible as the result of the most complex processes of life in the most complex of living organisms, has doubtless led to a belief in the identity of life with soul. But unless the use of the expression "soul" is extended to a degree which would deprive it of all special significance, the distinction between these terms must be strictly maintained. For the problems of life are essentially problems of matter; we cannot conceive of life in the scientific sense as existing apart from matter. The phenomena of life are investigated, and can only be investigated, by the same methods as all other phenomena of matter, and the general results of such investigations tend to show that living beings are governed by laws identical with those which govern inanimate matter. The more we study the manifestations of life, the more we become convinced of the truth of this statement and the less we are disposed to call in the aid of a special and unknown form of energy to explain those manifestations.

PHENOMENA INDICATIVE OF LIFE: MOVEMENT.

The most obvious manifestation of life is "spontaneous" movement. We see a man, a dog, a bird move, and we know that they are alive. We place a drop of pond water under the microscope, and see numberless particles rapidly moving within it; we affirm that it swarms with "life." We notice a small mass of clear slime changing its shape, throwing out projections of its structureless substance, creeping from one part of the field of the microscope to another. We recognize that the slime is living; we give it a name—*Amœba limax*—the slug amœba. We observe similar movements in individual cells of our own body; in the white corpuscles of our blood, in connective tissue cells, in growing nerve cells, in young cells everywhere. We denote the similarity between these movements and those of the amœba by employing the descriptive term "amœboid" for both. We regard such movements as indicative of the possession of "life"; nothing seems more justifiable than such an inference.

SIMILARITY OF MOVEMENTS IN LIVING AND NON-LIVING MATTER.

But physicists show us movements of a precisely similar character in substances which no one by any stretch of imagination can regard as living; movements of oil drops, of organic and inorganic mixtures, even of mercury globules, which are indistinguishable in their character from those of the living organisms we have been studying: movements which can only be described by the same term amœboid, yet obviously produced as the result of purely physical and chemical reactions causing changes in surface tension of the fluids under examination. It is therefore certain that such movements are not specifically "vital," that their presence does not necessarily denote "life." And when we investigate closely even such active movements as those of a vibratile cilium or a phenomenon so closely identified with life as the contraction of a muscle, we find that these present so many analogies with amœboid movements as to render it certain that they are fundamentally of the same character and produced in much the same manner. Nor can we for a moment doubt that the complex actions which are characteristic of the more highly differentiated organisms have been developed in the course of evolution from the simple movements characterizing the activity of undifferentiated protoplasm; movements which can themselves, as we have seen, be perfectly imitated by non-living material. The chain of evidence regarding this particular manifestation of life—movement—is complete. Whether exhibited as the amœboid movement of the proteus animalcule or of the white corpuscle of our blood; as the ciliary motion of the infusorian or of the ciliated cell; as the contraction of a muscle under the governance of the will, or as the throbbing of the human heart responsive to every emotion of the mind, we cannot but conclude that it is alike subject to and produced in conformity with the general laws of matter, by agencies resembling those which cause movements in lifeless material.

ASSIMILATION AND DISASSIMILATION.

It will perhaps be contended that the resemblances between the movements of living and non-living matter may be only superficial, and that the conclusion regarding their identity to which we are led will be dissipated when we endeavor to penetrate more deeply into the working of living substance. For can we not recognize along with the possession of movement the presence of other phenomena which are equally characteristic of life and with which non-living material is not endowed? Prominent among the characteristic phenomena of life are the processes of assimilation and disassimilation, the taking in of food and its elaboration. These, surely, it may be thought, are not shared by matter which is not endowed with life. Unfortunately for this argument, similar processes occur characteristically in situations which no one would think of associating with the presence of life. A striking example of this is afforded by the osmotic phenomena presented by solutions separated from one another by semi-permeable membranes or films, a condition which is precisely that which is constantly found in living matter.

CHEMICAL PHENOMENA ACCOMPANYING LIFE.

It is not so long ago that the chemistry of organic matter was thought to be entirely different from that of inorganic substances. But the line between inorganic and organic chemistry, which up to the middle of the last century appeared sharp, subsequently became misty and has now disappeared. Similarly the chemistry of living organisms, which is now a recognized branch of organic chemistry, but used to be considered as so much outside the domain of the chemist that it could only be dealt with by those whose special business it was to study "vital" processes, is passing every day more out of the hands of the biologist and into those of the pure chemist.

THE COLLOID CONSTITUTION OF LIVING MATTER.—IDENTITY OF PHYSICAL AND CHEMICAL PROCESSES IN LIVING AND NON-LIVING MATTER.

Somewhat more than half a century ago Thomas Graham published his epoch-making observations relating to the properties of matter in the colloidal state: observations which are proving all-important in assisting our comprehension of the properties of living substance. For it is becoming every day more apparent that the chemistry and physics of the living organism are essentially the chemistry and physics of nitrogenous colloids. Living substance or protoplasm always, in fact, takes the form of a colloidal solution. In this solution the colloids are associated with crystalloids (electrolytes), which are either free in the solution or attached to the molecules of the colloids. Surrounding and inclosing the living substance thus constituted of both colloid and crystalloid material is a film, probably also formed of colloid, but which may have a lipoid substratum associated with it (Overton). This film serves the purpose of an osmotic membrane, permitting of exchanges by diffusion between the colloidal solution constituting the protoplasm and the circumambient medium in which it lives. Other similar films or membranes occur in the interior of protoplasm. These films have in many cases specific characters, both physical and chemical, thus favoring the diffusion of special kinds of material into and out of the protoplasm and from one part of the protoplasm to another. It is the changes produced under these physical conditions, associated with those caused by active chemical agents formed within protoplasm and known as *enzymes*, that effect assimilation and disassimilation. Quite similar changes can be produced outside the body (*in vitro*) by the employment of methods of a purely physical and chemical nature. It is true that we are not yet familiar with all the intermediate stages of transformation of the materials which are taken in by a living body into the materials which are given out from it. But since the initial processes and the final results are the same as they would be on the assumption that the changes are brought about in conformity with the known laws of chemistry and physics, we may fairly conclude that all changes in living substance are brought about by ordinary chemical and physical forces.

SIMILARITY OF THE PROCESSES OF GROWTH AND REPRODUCTION IN LIVING AND NON-LIVING MATTER.

Should it be contended that growth and reproduction are properties possessed only by living bodies and constitute a test by which we may differentiate between life and non-life, between the animate and inanimate creation, it must be replied that no contention can be more fallacious. Inorganic crystals grow and multiply and reproduce their like, given a supply of the requisite pabulum. In most cases for each kind of crystal there is, as with living organisms, a limit of growth which is not exceeded, and further increase of the crystalline matter results not in further increase in size but in multiplication of similar crystals. Leduc has shown that the growth and division of artificial colloids of an inorganic nature, when placed in an appropriate medium, present singular resemblances to the phenomena of the growth and division of living organisms. Even so complex a process as the division of a cell-nucleus by karyokinesis as a preliminary to the multiplication of the cell by division—a phenomenon which would *prima facie* have seemed and has been commonly regarded as a distinctive manifestation of the life of the cell—can be imitated with solutions of a simple inorganic salt, such as chloride of sodium, containing a suspension of carbon particles; which arrange and rearrange themselves under the influence of the movements of the electrolytes in a manner indistinguishable from that adopted by the particles of chromatin in a dividing nucleus. And in the process of sexual reproduction, the researches of J. Loeb and others upon the ova of the sea-urchin have proved that we can no longer consider such an apparently vital phenomenon as the fertilization of the egg as being the result of living material brought to it by the spermatozoon, since it is possible to start the process of the ovum and the resulting formation of cells, and ultimately of all the tissues and organs—in short, to bring about the development of the whole body—if a simple chemical reagent is substituted for the male element in the process of fertilization. Indeed, even a mechanical or electrical stimulus may suffice to start development.

THE POSSIBILITY OF THE SYNTHESIS OF LIVING MATTER.

Further, in its chemical composition we are no longer compelled to consider living substance as possessing infinite complexity, as was thought to be the case when chemists first began to break up the proteins of the body into their simpler constituents. The researches of Miescher, which have been continued and elaborated by Kossel and his pupils, have acquainted us with the fact that a body so important for the nutritive and reproductive functions of the cell as the nucleus—which may be said indeed to represent the quintessence of cell-life—possesses a chemical constitution of no very great complexity; so that we may even hope some day to see the material which composes it prepared synthetically. And when we consider that the nucleus is not only itself formed of living substance, but is capable of causing other living substance to be built up; is, in fact, the directing agent in all the principal chemical changes which take place within the living cell, it must be admitted that we are a long step forward in our knowledge of the chemical basis of life. That it is the *form* of nuclear matter rather than its chemical and molecular structure which is the important factor in nuclear activity cannot be supposed. The form of nuclei, as every microscopist knows, varies infinitely, and there are numerous living organisms in which the nuclear matter is without form, appearing simply as granules distributed in the protoplasm. Not that the form assumed and the transformations undergone by the nucleus are without importance, but it is none the less true that even in an amorphous condition the material which in the ordinary cell takes the form of a "nucleus" may, in simpler organisms which have not in the process of evolution become complete cells, fulfil functions in many respects similar to those fulfilled by the nucleus of the more differentiated organism.

A similar anticipation regarding the probability of eventual synthetic production may be made for the proteins of the cell-substance. Considerable progress in this direction has indeed already been made by Emil Fischer, who has for many years been engaged in the task of building up the nitrogenous combinations which enter into the formation of the complex molecule of protein. It is satisfactory to know that the significance of the work both of Fischer and of Kossel in this field of biological chemistry has been recognized by the award to each of these distinguished chemists of a Nobel prize.

THE CHEMICAL CONSTITUTION OF LIVING SUBSTANCE.

The elements composing living substance are few in number. Those which are constantly present are carbon, hydrogen, oxygen, and nitrogen. With these, both in nuclear matter and also, but to a less degree, in the more diffuse living material which we know as protoplasm, phosphorus is always associated. "Ohne Phosphor kein Gedank" is an accepted aphorism; "Ohne Phosphor kein Leben" is equally true. Moreover, a large proportion, rarely less than 70 per cent, of water appears essential for any manifestation of life, although not in all cases necessary for its continuance, since organisms are known which will bear the loss of the greater part if not the whole of the water they contain without permanent impairment of their vitality. The presence of certain inorganic salts is no less essential, chief among them being chloride of sodium and salts of calcium, magnesium, potassium, and iron. The combination of these elements into a colloidal compound represents the chemical basis of life; and when the chemist succeeds in building up this compound it will without doubt be found to exhibit the phenomena which we are in the habit of associating with the term "life."

SOURCE OF LIFE.—THE POSSIBILITY OF SPONTANEOUS GENERATION.

The above considerations seem to point to the conclusion that the possibility of the production of life—i. e., of living material—is not so remote as has been generally assumed. Since the experiments of Pasteur, few have ventured to affirm a belief in the spontaneous generation of bacteria and monads and other microorganisms, although before his time this was by many believed to be of universal occurrence. My esteemed friend Dr. Charlton Bastian is, so far as I am aware, the only scientific man of eminence who still adheres to the old creed, and Dr. Bastian, in spite of numerous experiments and the publication of many books and papers, has not hitherto succeeded in winning over any converts to his opinion. I am myself so entirely convinced of the accuracy of the results which Pasteur obtained—are they not within the daily and hourly experience of everyone who deals with the sterilization of organic solutions?—that I do not hesitate to believe, if living torulæ or mycelia are exhibited to me in flasks which had been subjected to prolonged boiling after being hermetically sealed, that there has been some fallacy either in the premises or in the carrying out of the operation. The appearance of organisms in such flasks would not furnish to my mind proof that they were the result of spontaneous generation. Assuming no fault in manipulation or fallacy in observation, I should find it simpler to believe that the germs of such organisms have resisted the effects of prolonged heat than that they became generated spontaneously. If spontaneous generation is possible, we cannot expect it to take the form of living beings which show so marked a degree of differentiation, both structural and functional, as the organisms which are described as making their appearance in these experimental flasks. Nor should we expect the spontaneous generation of living substance of any kind to occur in a fluid the organic constituents of which have been so altered by heat that they can retain no sort of chemical resemblance to the organic constituents of living matter. If the formation of life—of living substance—is possible at the present day—and for my own part I see no reason to doubt it—a boiled infusion of organic matter—and still less of inorganic matter—is the last place in which to look for it. Our mistrust of such evidence as has yet been brought forward need not, however, preclude us from admitting the possibility of the formation of living from non-living substance.

LIFE A PRODUCT OF EVOLUTION.

Setting aside, as devoid of scientific foundation, the idea of immediate supernatural intervention in the first production of life, we are not only justified in believing, but compelled to believe, that living matter must have owed its origin to causes similar in character to those which have been instrumental in producing all other forms of matter in the universe; in other words, to a process of gradual evolution. But it has been customary of late among biologists to shelve the investigation of the mode of origin of life by evolution from

non-living matter by relegating its solution to some former condition of the earth's history, when, it is assumed, opportunities were accidentally favorable for the passage of inanimate matter into animate; such opportunities, it is also assumed, having never since recurred and being never likely to recur.

Various eminent scientific men have even supposed that life has not actually originated upon our globe, but has been brought to it from another planet or from another stellar system. Some of my audience may still remember the controversy that was excited when the theory of the origin of terrestial life by the intermediation of a meteorite was propounded by Sir William Thomson in his presidential address at the meeting of this association in Edinburgh in 1871. To this "meteorite" theory the apparently fatal objection was raised that it would take some sixty million years for a meteorite to travel from the nearest stellar system to our earth, and it is inconceivable that any kind of life could be maintained during such a period. Even from the nearest planet 150 years would be necessary, and the heating of the meteorite in passing through our atmosphere and at its impact with the earth would, in all probability, destroy any life which might have existed within it. A cognate theory, that of *cosmic panspermia*, assumes that life may exist and may have existed indefinitely in cosmic dust in the interstellar spaces (Richter, 1865; Cohn, 1872), and may with this dust fall slowly to the earth without undergoing the heating which is experienced by a meteorite. Arrhenius, who adopts this theory, states that if living germs were carried through the ether by luminous and other radiations the time necessary for their transportation from our globe to the nearest stellar system would be only nine thousand years, and to Mars only twenty days!

But the acceptance of such theories of the arrival of life on the earth does not bring us any nearer to a conception of its actual mode of origin; on the contrary, it merely serves to banish the investigation of the question to some conveniently inaccessible corner of the universe and leaves us in the unsatisfactory position of affirming not only that we have no knowledge as to the mode of origin of life—which is unfortunately true—but that we never can acquire such knowledge—which it is to be hoped is not true. Knowing what we know, and believing what we believe, as to the part played by evolution in the development of terrestrial matter, we are, I think (without denying the possibility of the existence of life in other parts of the universe), justified in regarding these cosmic theories as inherently improbable—at least in comparison with the solution of the problem which the evolutionary hypothesis offers.

THE EVOLUTIONARY HYPOTHESIS AS APPLIED TO THE ORIGIN OF LIFE.

I assume that the majority of my audience have at least a general idea of the scope of this hypothesis, the general acceptance of which has within the last sixty years altered the whole aspect not only of biology, but of every other branch of natural science, including astronomy, geology, physics, and chemistry. To those who have not this familiarity I would recommend the perusal of a little book by Prof. Judd entitled "The Coming of Evolution," which has recently appeared as one of the Cambridge manuals. I know of no similar book in which the subject is as clearly and succinctly treated. Although the author nowhere expresses the opinion that the actual origin of life on the earth has arisen by evolution from non-living matter, it is impossible to read either this or any similar exposition in which the essential unity of the evolutionary process is insisted upon without concluding that the origin of life must have been due to the same process, this process being, without exception, continuous, and admitting of no gap at any part of its course. Looking, therefore, at the evolution of living matter by the light which is shed upon it from the study of the evolution of matter in general, we are led to regard it as having been produced, not by a sudden alteration, whether exerted by natural or supernatural agency, but by a gradual process of change from material which was lifeless through material on the borderland between inanimate and animate, to material which has all the characteristics to which we attach the term "life." So far from expecting a sudden leap from an inorganic, or at least an unorganized, into an organic and organized condition, from an entirely inanimate substance to a completely animate state of being, should we not rather expect a gradual procession of changes from inorganic to organic matter, through stages of gradually increasing complexity until material which can be termed living is attained? And in place of looking for the production of fully formed living organisms in hermetically sealed flasks, should we not rather search Nature herself, under natural conditions, for evidence of the existence, either in the past or in the present, of transitional forms between living and non-living matter?

The difficulty, nay, the impossibility, of obtaining evidence of such evolution from the past history of the globe is obvious. Both the hypothetical transitional material and the living material which was originally evolved from it may, as Macallum has suggested, have taken the form of diffused ultramicroscopic particles of living substance; and even if they were not diffused but aggregated into masses, these masses could have been physically nothing more than colloidal watery slime which would leave no impress upon any geological formation. Myriads of years may have elapsed before some sort of skeleton in the shape of calcareous or siliceous spicules began to evolve itself, and thus enabled "life," which must already have possessed a prolonged existence, to make any sort of geological record. It follows that in attempting to pursue the evolution of living matter to its beginning in terrestrial history we can only expect to be confronted with a blank wall of nescience.

The problem would appear to be hopeless of ultimate solution if we are rigidly confined to the supposition that the evolution of life has only occurred once in the past history of the globe. But are we justified in assuming that at one period only, and as it were by a fortunate and fortuitous concomitation of substance and circumstance, living matter became evolved out of non-living matter—life became established? Is there any valid reason to conclude that at some previous period of its history our earth was more favorably circumstanced for the production of life than it is now? I have vainly sought for such reason, and if none be forthcoming the conclusion forces itself upon us that the evolution of non-living into living substance has happened more than once—and we can be by no means sure that it may not be happening still.

It is true that up to the present there is no evidence of such happening; no process of transition has hitherto been observed. But, on the other hand, is it not equally true that the kind of evidence which would be of any real value in determining this question has not hitherto been looked for? We may be certain that if life is being produced from non-living substance, it will be life of a far simpler character than any that has yet been observed—in material which we shall be uncertain whether to call animate or inanimate, even if we are able to detect it at all, and which we may not be able to visualize physically even after we have become convinced of its existence. But we can look with the mind's eye and follow in imagination the transformation which non-living matter may have undergone and may still be undergoing to produce living substance. No principle of evolution is better founded than that insisted upon by Sir Charles Lyell, justly termed by Huxley "the greatest geologist of his time," that we must interpret the past history of our globe by the present; that we must seek for an explanation of what has happened by the study of what is happening; that, given similar circumstances, what has occurred at one time will probably occur at another. The process of evolution is universal. The inorganic materials of the globe are continually undergoing transition. New chemical combinations are constantly being formed and old ones broken up; new elements are making their appearance and old elements disappearing. Well may we ask ourselves why the production of living matter alone should be subject to other laws than those which have produced, and are producing, the various forms of non-living matter; why what has happened may not happen. If living matter has been evolved from lifeless in the past, we are justified in accepting the conclusion that its evolution is possible in the present and in the future. Indeed, we are not only justified in accepting this conclusion, we are forced to accept it. When or where such change from non-living to living matter may first have occurred, when or where it may have continued, when or where it may still be occurring, are problems as difficult as they are interesting, but we have no right to assume that they are insoluble.

Since living matter always contains water as its most abundant constituent, and since the first living organisms recognizable as such in the geological series were aquatic, it has generally been assumed that life must first have made its appearance in the depths of the ocean. Is it, however, certain that the assumption that life originated in the sea is correct? Is not the land-surface of our globe quite as likely to have been the nidus for the evolutionary transformation of non-living into living material as the waters which surround it? Within this soil almost any chemical transformation may occur; it is subjected much more than matters dissolved in sea-water to those fluctuations of moisture, temperature, electricity, and luminosity which are potent in producing chemical changes. But whether life, in the form of a simple slimy colloid, originated in the depths of the sea or on the surface of the land, it would be equally impossible for the geologist to trace its beginnings, and were it still becoming evolved in the same situations, it would be almost as impossible for the microscopist to follow its evolution. We are therefore not likely to obtain direct evidence regarding such a transformation of non-living into living matter in nature, even if it is occurring under our eyes.

An obvious objection to the idea that the production of living matter from non-living has happened more than once is that, had this been the case, the geological record should reveal more than one palæontological series. This objection assumes that evolution would in every case take an exactly similar course and proceed to the same goal—an assumption which is, to say the least, improbable. If, as might well be the case, in any other palæontological series than the one with which we are acquainted the process of evolution of living beings did not proceed beyond Protista, there would be no obvious geological evidence regarding it; such evidence would only be discoverable by a carefully directed search made with that particular object in view. I would not by any means minimize the difficulties which attend the suggestion that the evolution of life may have occurred more than once or may still be happening, but, on the other hand, it must not be ignored that those which attend the assumption that the production of life has occurred once only are equally serious. Indeed, had the idea of the possibility of a multiple evolution of living substance been first in the field, I doubt if the prevalent belief regarding a single fortuitous production of life upon the globe would have become established among biologists—so much are we liable to be influenced by the impressions we receive in scientific childhood!

(To be continued.)

The "Minister's Son"

IN a recent number of the *Popular Science Monthly* C. E. Macartney discusses the old question of the "minister's son." A long time ago Thomas Fuller wrote: "There goeth forth a common report, no less uncharitable than untrue, as if clergymen's sons were generally unfortunate like the sons of Eli, dissolute in their lives and doleful in their deaths."

The author cites the following significant facts which brilliantly vindicate the much abused "minister's son."

"In the 'Dictionary of National Biography,' England, there are 1,270 names of eminent men who were sons of clergymen. There are 510 names of famous men who were sons of lawyers, and 350 who were sons of physicians. In this single compilation of great names in English history there are 410 more sons of ministers than sons of doctors and lawyers together. In a recent issue of 'Who's Who,' for America, out of nearly 12,000 names, almost 1,000 are sons of clergymen, a number out of all proportion to the whole number of ministers in the population of the country. According to that standard, there should have been not more than fifty of these famous men the sons of clergy.

"Time would fail to tell of all the notable men in all departments of human activity who were sons of ministers. We mention only a few of these. In science, Agassiz, Fabricius, Jenner, Linnæus, Olbers, Fields, Morse, Berzelius, Euler; in history and philosophy, George John Romannes, John G. Wilkinson, Hallam, Hobbes, Froude, Sloan, Parkman, Bancroft, Schnelling, Schliermacher, Nietzsche, Müller; in art, Reynolds and Christopher Wren; in philanthropy, Clarkson and Granville Sharp, the anti-slavery agitators; in poetry, Lessing, Tennyson, Ben Jonson, Cowper, Goldsmith, Thomson, Coleridge, Addison, Young, John Keble, Matthew Arnold; among essayists, Emerson, Richter, Hazlitt; among novelists, Charles Kingsley, Henry James, and three daughters of clergymen, Jane Austen, Charlotte Brontë, and Harriet Beecher Stowe.

"But most remarkable is the long list of celebrated divines who were themselves sons of ministers. Among such are these names, Swedenborg, the seer, Jonathan Edwards, Archibald Hodge, Henry Ward Beecher, Lyman Abbott, Charles Spurgeon, Increase and Cotton Mather, Matthew Henry, the famous commentator; Frederick D. Maurice, Lightfoot, John and Charles Wesley, Mansell, Dorner and Dean Stanley.

"In our American history the Field family is a noble example of the influence of clerical households. The father, the Rev. David D. Field, was a minister of the Congregational church. One son, David Dudley, was the eminent jurist and law reformer; another, Stephen J., was an associate justice of the Supreme Court; a third is known as an author, and the fourth son was Cyrus W., who laid the Atlantic cable.

"It is probable that ministers' sons have exerted more influence in the United States than in any other country. Among teachers, lawyers, doctors, scientists, men of business, and in the church, there are a great host who have been the sons of the manse. In the Hall of Fame fifty-one of our famous Americans are honored. Of these fifty-one, ten are the children of ministers: Agassiz, Beecher, Harriet Beecher Stowe, Henry Clay, Jonathan Edwards, Emerson, Lowell, Morse, Bancroft, Holmes."

Trade Notes and Formulæ

To Polish Aluminium, all grease should first be removed by pumice stone; then, according to *Drogisten Rundschau* a paste made of emery and tallow, applied with a polishing brush, is used to produce brilliancy. Finally rouge and turpentine should be used.

Waterproof Glue Cement for Wooden Vessels.—Ten parts of thick glue solution, 5 parts linseed oil varnish, 1 part litharge, boiled together for ten minutes and used hot is recommended by *Neueste Erfindungen und Erfahrungen*. This cement may be used for water tubs but not for lye tubs.

Transparent and Shining Paste.—Use 2 parts dextrine, 1 part acetic acid, 1 part alcohol, 5 parts water. In making up the preparation, the dextrine is first dissolved in water, then the acetic acid added and then gradually the alcohol, while shaking. This results at first in a cloudiness, which, however, after shaking, again disappears.—*Pharmazeutische Zeitung.*

Rubber Cement for Glass.—Dissolve 15 parts caoutchouc in 60 parts chloroform, add to the solution about 35 parts mastic and allow the mixture to stand, without the application of heat, for about 8 days. The cement should be applied to the surface, says *Zeitung fur Optik und Mechanik*, by means of a brush and is transparent. If greater elasticity is desired, use more caoutchouc.

Removing Grass.—The growth of grass in the interstices between paving stones may be prevented, says *Pharmazeutische Zeitung*, by repeatedly sprinkling the pavement with a 5 per cent solution of the very cheap, crude, dry chloride of calcium or crude chloride of magnesium. Also the lye of potash works is said to give good results for this purpose. By others, sprinkling with boiling hot water is given as a good remedy. Furthermore, gas liquor, rock salt, hydrochloric acid, sulphuric acid and fresh milk of lime are also recommended.

Machine Glazes.—Machine glazes are commonly used for painting agricultural machinery and are furnished in the most varied colors, such as green, red, blue, etc. They must possess great brilliancy and must adhere to the iron almost as inseparably as enamel. They may be produced, says *Lack-und Farbenindustrie*, of exceptional excellence according to the following recipe: In 120 parts, 95 per cent alcohol, dissolve 80 parts soft Manila copal and 40 parts rosin and, solution being completed, add 30 parts castor oil. This lacquer is then rubbed down in the proportion of 4 to 7 with any desired bright color.

Rubber Cement.—To impart to the cement somewhat greater hardness, gutta-percha is substituted for a portion of the caoutchouc; a recipe especially adapted for the production of a cement for stopping holes in the outer cover of automobile tires is prepared, according to *Technische Rundschau*, as follows: 160 parts sulphide of carbon, 20 parts gutta-percha, 40 parts caoutchouc, 10 parts isinglass. The last should probably be used in a thick, water-swelled condition. Some also recommend the addition of rosin, especially gum dammar or rosin, which imparts greater adhesiveness to the cement. The solution of caoutchouc, in sulphide of carbon, serves usually only as an adhesive for the attachment to the damaged spot of a piece of fabric. A very strongly adhesive mixture is obtained from 4 parts caoutchouc, 16 parts benzine, 8 parts rosin, and 6 parts Japan wax. It is advisable to coat the places repaired with the cement with a diluted solution of chloride of sulphur in benzol, as this effects the vulcanization of the upper stratum, i. e., hardens it and causes it to lose its stickiness.

Mother-of-Pearl Varnish.—All varnishes, lacquers and cellulose solutions can only yield a shining coating if perfectly free from water; if therefore we wish to obtain a brilliant mother-of-pearl varnish, says the *Revue des Produits Chimiques*, we must remove from the pearl-scales (fish-scales) all moisture. The process consists chiefly in the mixing of the pearl scales with the varnish and in the complete absorption of any water contained in the mixture by means of a dehydrating agent. For this purpose gelatine, agar-agar or albuminous substances are used. The following process has hitherto proved satisfactory. With a spoon, the pearl scales are taken and placed in a solution of celluloid or collodion in aceto-amyl alcohol. It must be stirred until the scales remain suspended in the mixture. As the water that is always contained in the scales does not unite with the amyl acetate it is divided into exceedingly fine drops that remain suspended in the mixture. For this reason, flake gelatine is introduced into the mixture. The gelatine, which is perfectly insoluble in acetate of amyl, absorbs all the water without being itself dissolved or changing its form. As soon as the gelatine is hard the process is completed. With rosin varnishes the mode of procedure is the same, the pearl-scales being mixed with the varnish and the water absorbed as above described. By this means a brilliant mother-of-pearl varnish is easily obtained for the imitation of pearls and mother-of-pearl.

Science Notes

Lead Poisoning.—Speaking of this subject, Dr. Gilman Thompson remarks: "There is great personal idiosyncrasy regarding susceptibility to lead poisoning, some persons being easily poisoned after short periods of exposure, and others remaining apparently immune for several years. Children are more susceptible than adults. A boy of thirteen years came lately to my clinic in the Cornell University Medical College, who had been employed for four months in cleaning paint cans, and with advanced symptoms of lead poisoning. A young man of twenty-one years who had been a helper for eight years in a lead smelting works, had an enormously dilated heart, the senile arteries of an octogenarian, chronic Bright's disease and other serious symptoms, ruining his health hopelessly. On the other hand, I have seen painters who had handled white lead paints for thirty years or more before they presented symptoms of poisoning serious enough to put them out of employment."

The Volatility of Platinum Crucibles.—One is rather inclined to suppose that a platinum crucible is almost indestructible if carefully used. It is true, as every chemist knows, that when improperly handled, it is subject to very considerable deterioration, as for example, if the smoky flame is allowed to play on it, or if certain materials are ignited therein. These are points of which every beginner is warned by text book or oral instruction. Not so well known the fact that there is quite an appreciable loss of platinum by volatility of high temperatures. Sir William Crookes, in a communication to the Royal Society, points out that at 1,300 deg. Cent. platinum loses ten one thousandths of its weight per hour. Similarly paladium loses seven one thousandths of its weight, and iridium eight one thousandths. The losses of the latter are due principally to the fact that it become oxidized and the oxide formed is very volatile. With rhodium no losses were observed. At temperatures below 900 there is practically no loss, and iridium retains its physical character better than platinum.

The Electric Motor as a Substitute for the Brain.—That the function of the human brain can in certain cases be fulfilled by mechanical devices has long been understood and has led among other things to the construction of various calculating machines, which are of the highest practical utility, to say nothing of such scientific curiosities as the "logical machine." But the ordinary calculating machine still requires a human agent to manipulate it. It is a rather obvious step to eliminate this feature and render the device entirely mechanical, by working it with the aid of an electromotor. This, indeed, is now a fairly common practice, though, of course, it still leaves it to the operator to perform the actual setting up of the figures to be added, multiplied or the like. The possible improvements do not, however, end here. Machines have been made which do a great deal more; upon being fed with the requisite data in the form of perforated bands or cards, they will tabulate such data, total them up, and perform other operations. One such machine will add fifty thousand seven-figure numbers in one hour without any human assistance of any kind. Machines of this kind found extensive application during the last census in Germany.—*Die Welt der Technik.*

The Influence of the Gradient of the Road Upon the Speed of Pedestrians.—Every one knows that any considerable rise in the pathway has an appreciable effect upon the speed of one's progress. It is not so well known that even very slight gradients occasion quite considerable losses of time and energy to the pedestrian. Observations were made in a thoroughfare of New York city. It was found that on a horizontal stretch men moving with active step (i. e., not merely taking a walk) required on an average fourteen seconds to cover one hundred feet, while women, under similar conditions, took from twenty to twenty-two seconds. Groups of people invariably move more slowly than individuals. After climbing a certain gradient which formed parts of the road observed, the men had reduced their velocity so that now one hundred feet were covered in seventeen to twenty-one seconds; the corresponding figure for the women was twenty-one to twenty-five. Furthermore, it was found that the slowing down extended not only over the actual gradient, but for some hundred feet beyond, after reaching a level stretch. Another peculiar observation is that on first reaching a gradient the men continue for a time with their speed on the level, and only gradually slow down, while women slow down immediately upon striking a gradient.—*Prometheus.*

A Telephone Time Saver.—What looks like a good suggestion is a device noted in a recent number of the *Electrician*, an invention designated as a telephone time saver. This device consists of a sound-magnifying trumpet, of flattened form, similar to certain types of motor horns, behind which is a platform adapted to support the telephone receiver. Upon receiving or making a call upon the 'phone and being asked to "hold the line," the user, instead of "holding on" with the telephone receiver pressed to his ear, an arrangement which restricts his movements and prevents him from giving his attention to any other matter, merely drops the receiver on to the platform of the "time saver," where it automatically slides into position with the earpiece against the small end of the spiral trumpet. The user is then free to go on with his work until the voice from the trumpet shows him that the person at the other end is speaking. Conversation can then either be carried on using the loud-speaking trumpet, with the advantage of leaving the user's hands both free for the purpose of turning up references, taking down a message from dictation, etc., or the receiver may be lifted off the instrument and used in the ordinary way. The loud-speaking telephone's "voice" is very similar to that of a gramophone and it is thus possible for the user of one of these instruments to move some little way from the telephone and yet hear when the person at the other end of the line is speaking.

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SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, OCTOBER 5, 1912

Published weekly by Munn & Co., Inc. Charles Allen Munn, President Frederick Converse Beach, Secretary and Treasurer; all at 361 Broadway, New York

Entered at the Post Office of New York, N. Y., as Second Class Matter

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The Scientific American Publications

Scientific American Supplement (established 1876). . per year $5.00
Scientific American (established 1845) . . . . . " 3.00
American Homes and Gardens . . . . . " 3.00
The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Table of Contents

	PAGE.
A Controversy on Life.—2 illustrations	209
The Bubonic Plague.—II.—By Howard D. King	210
Photographic Observation of Comet 1911 c (Brooks).—E. E. Barnard	211
The Horse-power and Kilowatt	211
Discovering Utilities in Desert Crops.—By Z. E. Black.—3 illustrations	212
A Thirty-ton Electric Traverser for Serving Annealing Furnaces.—22 illustrations	213
An Experimental Study of Vortex Motion in Liquids.—II.—By Edwin F. Northrup.—1 illustration	215
Falsification of Evidence by Suggestion	215
A Chapter in Industrial Sanitation.—By J. C. B. Kershaw.—8 illustrations	216
Potash Silica and Alumina from Feldspar.—By Edward Hart	217
Electrolysis from Stray Currents.—III.—By Albert F. Gans.—1 illustration	218
Phosphorus and Its Compounds.—By Edwy Goodwin Clayton	219
Sinhalese Iron and Steel of Ancient Origin.—I.—By Sir Robert Hadfield.—7 illustrations	220
The Nature, Origin and Maintenance of Life.—By Prof. E. A. Shäfer	221
The "Minister's Son"	223
Trade Notes and Formulæ	224
Science Notes	224

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PAGE.
..... 209
..... 210
oks).—
..... 211
..... 211
Black.
..... 213
nealing
..... 213
uids.—
..... 215
..... 215
S. Ker-
..... 216
Edward
..... 217
bert F.
..... 218
oodwin
..... 219
By Sir
..... 220
y Prof.
..... 221
..... 223
..... 226
..... 224